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THE SECOND ANNUAL REPORT ON THE EFFECTS OF SIMULATED HAIL ON PROCESSING TOMATOES AND CUCUMBERS - 1987

BY

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The Second Annual Report On The Effects of Simulated Hail on Processing Tomatoes and Cucumbers - 1987

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This was the second year of the proposed 3-year study. Some objectives were more refined as a result of the studies done in 1986. A considerable amount of information was obtained and fortunately much data confirmed results found in 1986.

Objectives for 1987 were,

1. To develop a plant development classification (staging) of transplanted and field seeded processing tomatoes.
2. To determine the influence of a range of hail injury at several stages of plant development of transplanted and field seeded processing tomatoes on subsequent maturity and yield.
3. To determine the influence of early stand loss on maturity and yield of transplanted processing tomatoes (a new objective for 1987).
4. To determine the influence of hail injury on maturity and yield of pickling cucumbers (also a new objective).

Field plots were established at the OARDC Vegetable Crops Branch near Fremont, Ohio under conditions similar to the 1986 study. Transplants and seed of processing varieties were obtained through the courtesy of the H.J. Heinz Company, Fremont. Plants for the fresh market study were obtained from a local grower with the assistance of Mr. Ron Overmyer, the Sandusky County Agricultural Extension Agent. Seed for the cucumber study was also supplied by the H.J. Heinz Company.

The plots were established following standard commercial practice. Cultural care was uniform over all plots of a particular study and also followed standard practices. No exceptions were made in any cultural technique to the experimental plots. The weather conditions were different from the 1986 season, but not too much different

from "normal" whatever that is: May was warmer and drier than normal; June and July were warmer and wetter than normal, and August and September were about normal. The high temperatures in June and July caused the tomato plants to grow very rapidly and resulted in excessive vegetative growth and a longer-than-normal flowering and fruit setting period. The excessive and nearly continuous rainfall in late June and early July caused some problems with excessive tomato fruit rotting during the later stages of ripe fruit accumulation just prior to harvest. The processing tomatoes were harvested by machine and the fresh market tomatoes and pickling cucumbers were picked by hand.

DESCRIPTION OF EXPERIMENTS

A. Early Hail Injury and Stand Loss of Processing Tomatoes

This study was established on May 21, 1987, using Heinz 1810 transplants in single- and twin-row configuration. The single rows had 12 inches between plants and the twin rows were 16 inches apart with plants 18 inches apart. Two dates of simulated hail and stand reduction were used: June 1 and June 10 for simulated hail and May 29 and June 10 for plant removal. Hail treatments were none, slight, moderate and severe hail and plant removal treatments were none, 15% pulled and 30% pulled. Weather conditions prevented the planned times for treatment--2 and 3 weeks after transplanting. Harvest was done by machine on September 3 and 5, 1987.

B. Simulated Hail Transplants--Processing Tomatoes

Transplants of Heinz 1810 were planted on May 21, June 1 and June 10 on single-row and twin-row configurations. Spacings were the same as "A" above. The hail treatments were made at 2 days, June 29 and July 23 and consisted of none, slight, moderate and severe injury. Defoliation values to establish injury levels were made by a team of hail adjusters familiar with such damage. This was usually done 1-3 days following hail treatment.

The plots were machine harvested on September 1 (planting #1), September 14 (planting #2), and September 14 and 21 (planting #3) with fruits being divided into ripes, greens and rots. The fourth replication was not harvested, so it could be used to determine the actual delay in maturity caused by the hail treatments.

C. Simulated Hail--Field-Seeded Processing Tomatoes

Seed of Heinz 1810 were seeded on May 7 using standard procedures. Dates of hail treatments were July 10 and August 13. A mid-June treatment was scheduled but rainy, wet conditions precluded making this treatment. This experiment had all single-row plots. Treatments were the same as "B" above and harvest was done by machine on September 21, 1987.

D. Plant Development for Staging of Processing Tomatoes

Detailed observations were made on plants growing in the field relative to plant growth and development and sequencing of flowering, fruit setting and fruit growth and maturity. These observations were combined with data from 1986 to establish a reasonable description of stages of growth of the processing tomato.

E. Simulated Hail--Fresh Market Tomatoes

This study was nearly identical to the study done in 1986. Transplants of "Sunny" were planted on May 8 and May 29. Staking, cultural care, harvesting and grading were similar to commercial practice. Hail treatments were scheduled for late June and late July, but wet soil conditions caused the June treatment to be applied on June 29 to replications 3 and 4 and on July 9 to replications 1 and 2. The July treatment was made on July 23. Hail treatments were the same as "B" above.

F. Simulated Hail--Processing Cucumbers

Seeds of "Carolina" were planted on June 16. Hail treatments were none, slight, moderate and severe and were made at 3 stages of development; 1) vine tip (July 7); 2) first fruit size up to 1 inch in diameter (July 23); and 3) during the second week of harvest (July 31). Defoliation ratings were made 1-2 days after treatment by OARDC

personnel. The plots were harvested 7 times by hand (twice each week) and graded using standard procedures.

G. General Experimental Design

Plot rows in these studies were 30 ft. long except for the fresh market, staked tomatoes, which were 15 ft. long. Rows were spread 5 ft. apart except for twin rows, which were on beds on 5-ft. centers. The plots were replicated 4 times and both randomized complete block and split-plot designs used. Cultural procedures were based upon recommended commercial practices.

Statistical analyses were done on collected data but the actual defoliation data were used as treatment comparison for the processing tomato transplant studies. The previous year comparisons were based on the treatments none, slight, moderate and severe, but due to several factors, these were not always accomplished when treating the plants.

RESULTS

A. Early Hail and Stand Loss

The plants had recovered well after transplanting when the first hail treatments were made 11 days after transplanting. New growth ranged from 0.5 to 2.0 inches in length as axillary shoots. Nine days later when the second treatment was made, the axillary shoots were 3 to 5 inches long and a few plants had a blossom open on the first cluster of the main stem. This rapid early growth was more than normal because of the higher temperatures and more favorable rainfall than normal.

Yield data from these treatments are illustrated in Figures 1-4. In general, the total yield of ripes, greens and rots were reduced as the amount of defoliation increased. This response occurred at both spacings, but the data suggest that the effects were less in the twin-row plots. Green fruit data (Figs. 5 & 6) suggest that maturity was delayed from the hail injury and the more severe the injury, the greater delay. Also, the twin rows seemed less affected.

Adverse weather conditions caused some problems in determining precise delay in maturity effects from the hail treatments as planned from replication No. 4. The results do suggest that the slight hail treatment delayed maturity up to 5 days; moderate hail from 6 to 8 days and severe hail from 6 to nearly 10 days. Fruit rots greatly confused these observations.

The amount of fruit rots in any crop is generally related to fruit ripeness; i.e., the greater the amount of ripe fruits, especially over-ripe fruits, the greater will be the amount of rots. Data from this trial follows this trend, the less mature (greater amount of greens) the crop, the fewer the rots (data not presented here).

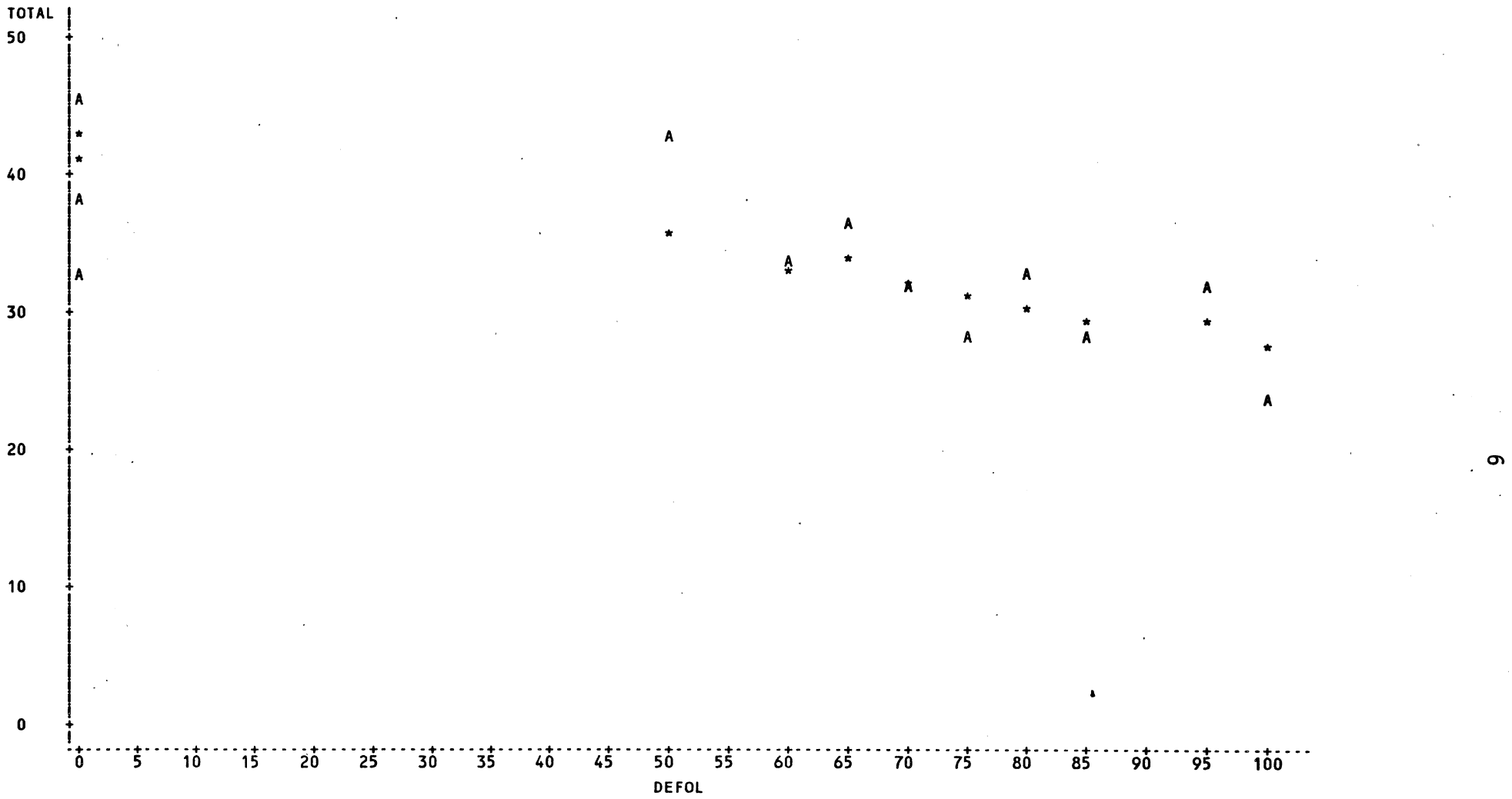
Results from the stand reduction study (Table 1) indicate that loss of stand generally results in lower yields. There appears to be a slight suggestion than maturity is delayed when stand is reduced. However, this needs to be repeated to more clearly establish this issue. There appears also to be considerable variability in response to stand reduction.

Table 1. Influence of stand reduction on yield of processing tomatoes

Stand reduction	Days after planting	Yield-tons/acre							
		Single rows				Twin rows			
		Ripe	Green	Rots	Total	Ripe	Green	Rots	Total
0	8	24.0	3.5	11.2	38.7	30.3	1.5	15.8	47.7
15%	8	23.1	4.5	11.9	39.5	27.2	1.4	13.0	41.5
30%	8	19.0	5.0	10.5	34.5	26.4	3.3	11.7	41.4
0	20	25.3	3.7	14.2	43.2	30.8	1.1	12.9	44.8
15%	20	21.6	4.6	11.6	37.8	26.6	3.2	11.7	41.5
30%	20	21.0	5.0	11.0	37.0	28.4	1.4	11.9	41.7
LSD 5%		6.5	NS	3.2	NS	6.5	1.9	3.2	NS

TIME=1 SPACING=1

PLOT OF TOTAL*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PTOT*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HIDDEN

Fig. 1. Relationship of amount of early hail injury to total yield of processing tomatoes - hail treatment 11 days after planting, single rows.

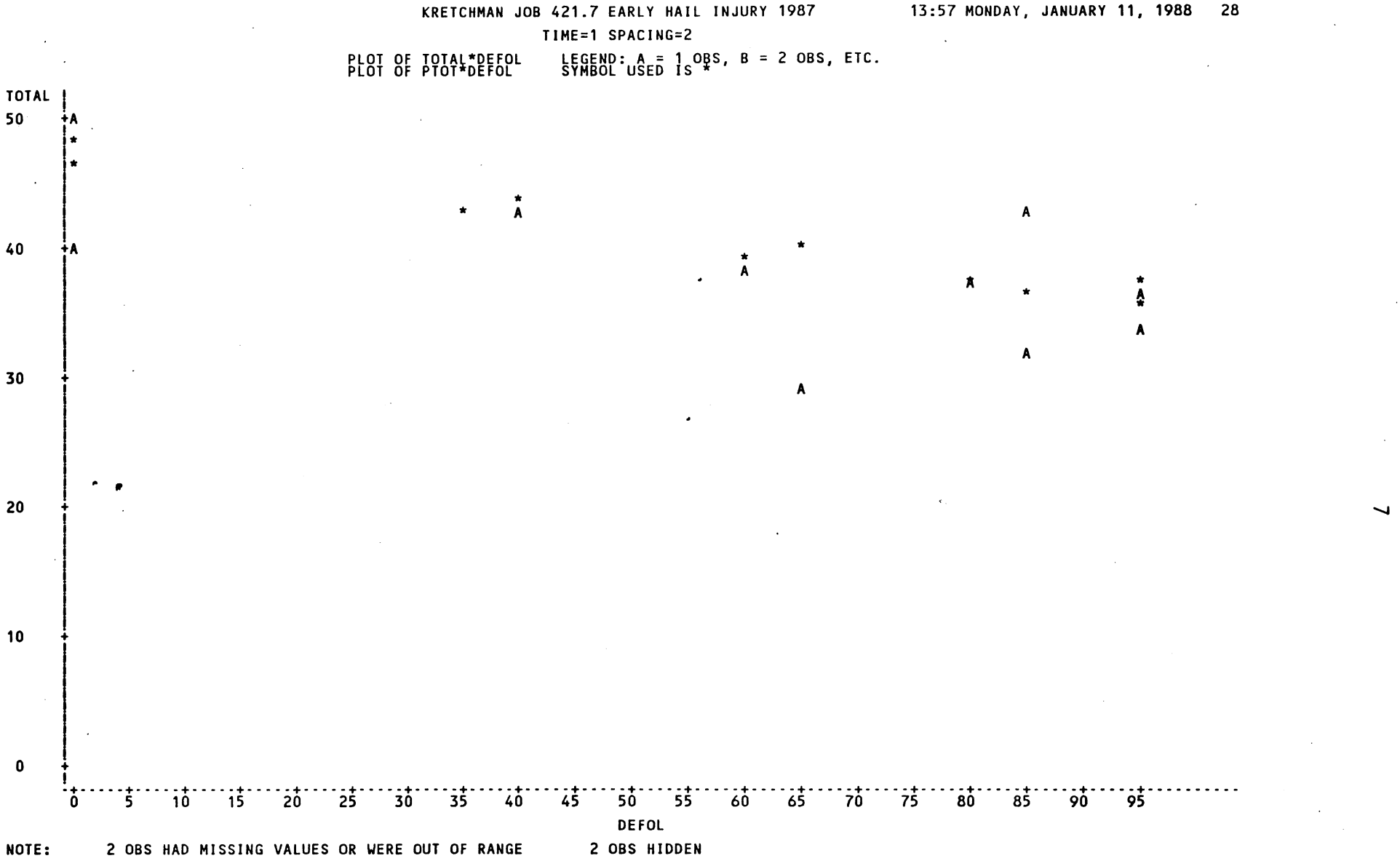


Fig. 2. Relationship of amount of early hail injury to total yield of processing tomatoes - hail treatment 11 days after planting, twin rows.

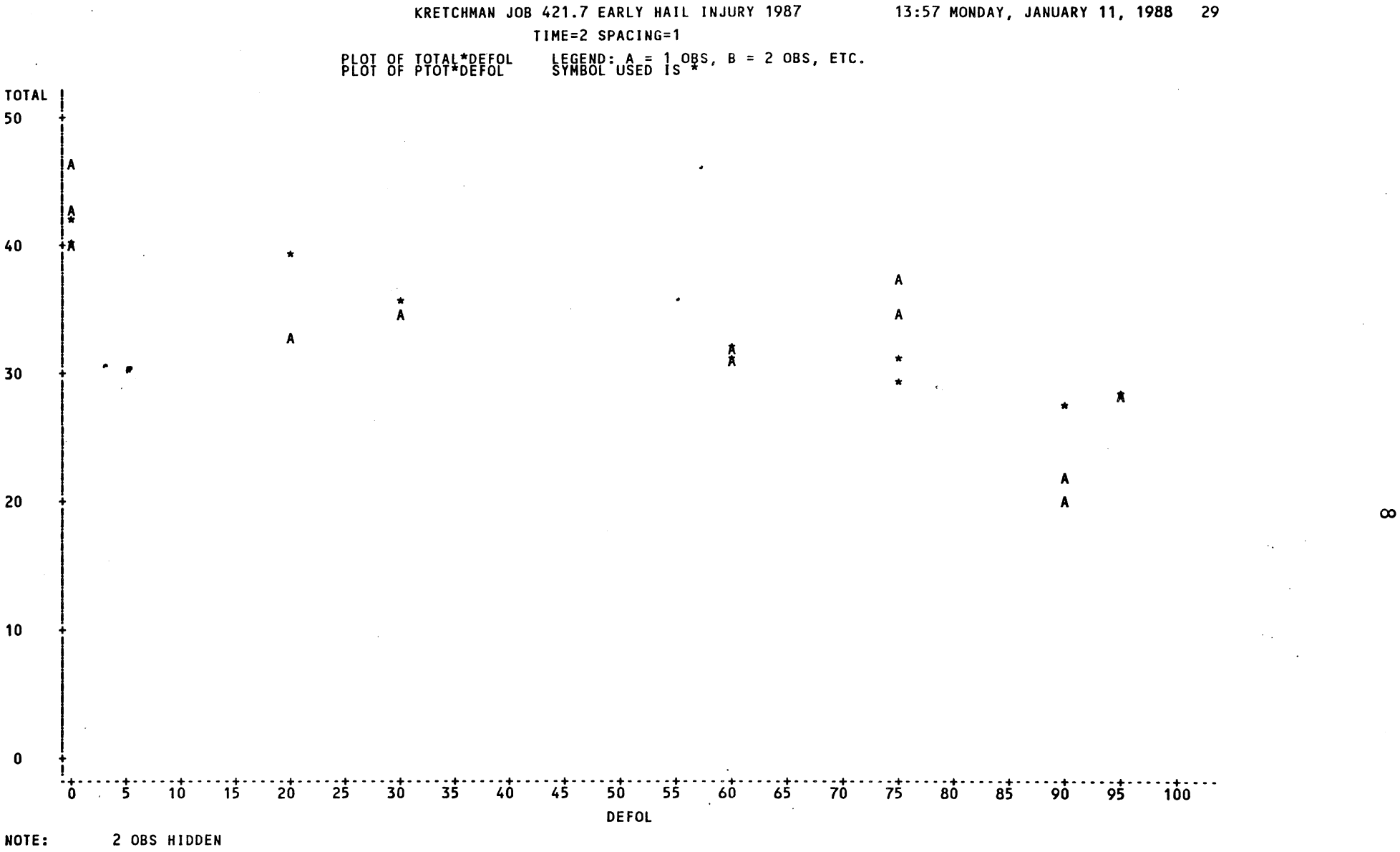


Fig. 3. Relationship of amount of early hail injury to total yield of processing tomatoes - hail treatment 20 days after planting, single rows.

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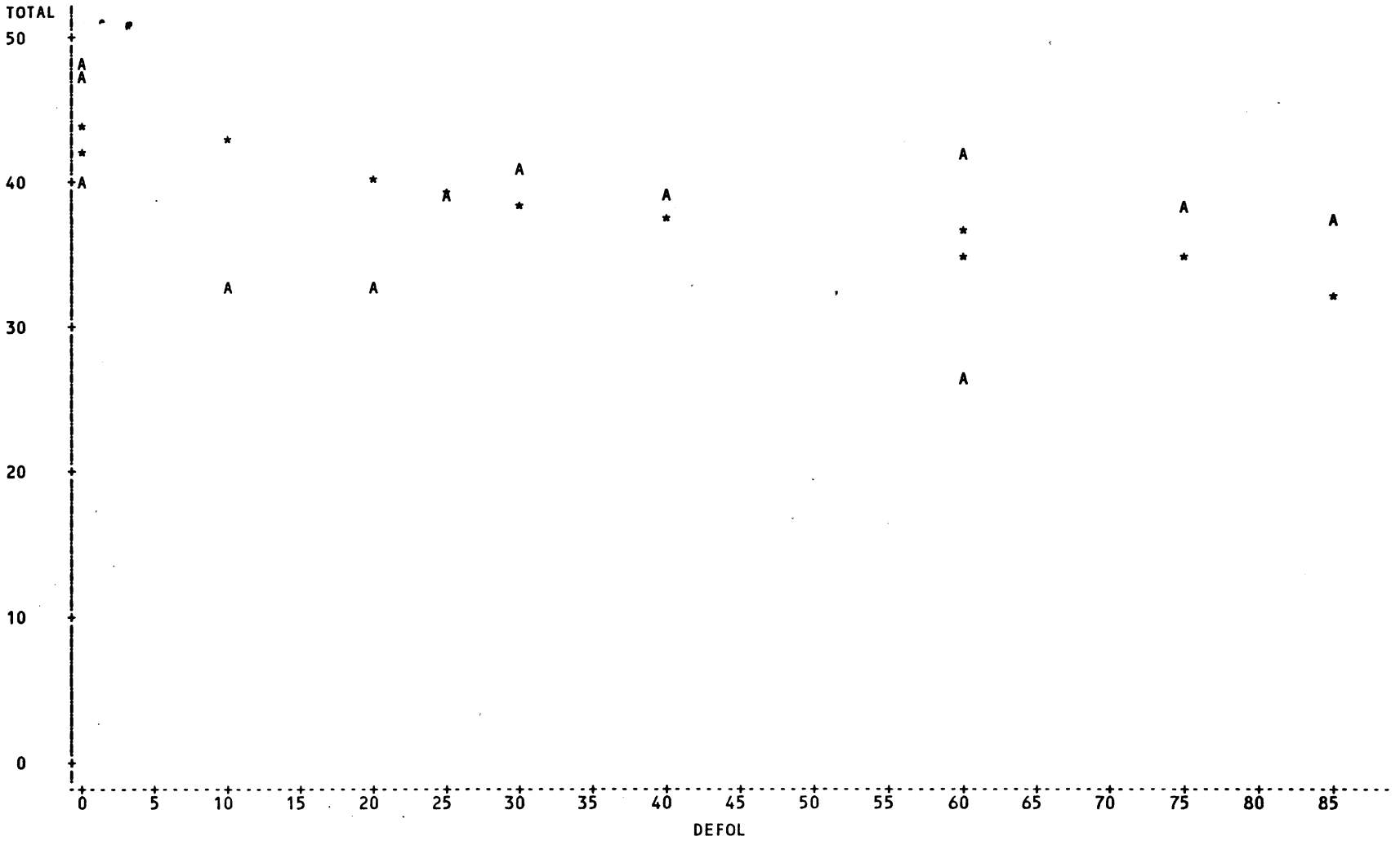
PLOT OF TOTAL*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PTOT*DEFOL SYMBOL USED IS *

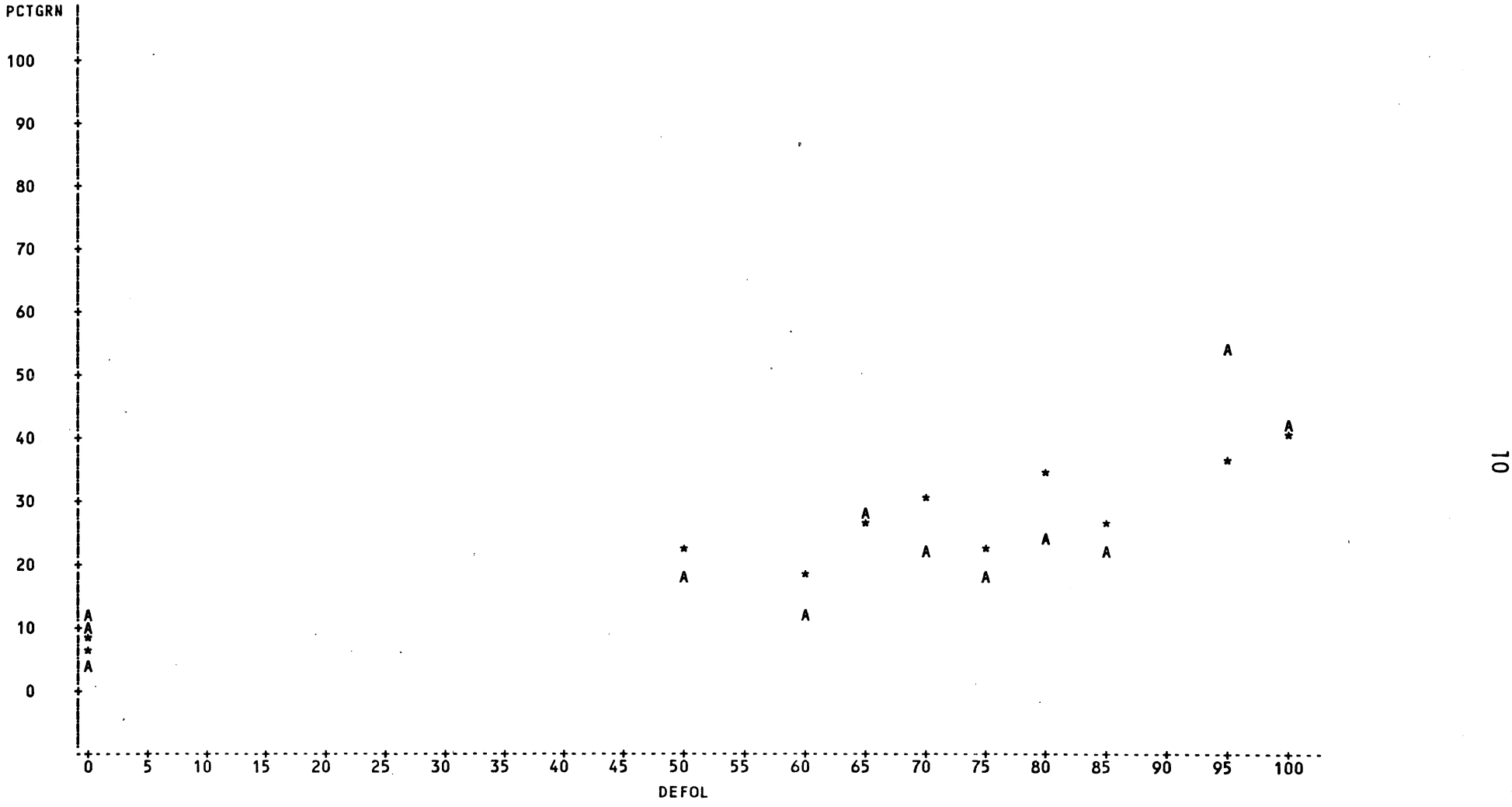


NOTE: 1 OBS HIDDEN

Fig. 4. Relationship of amount of early hail injury to total yield of processing tomatoes - hail treatment 20 days after planting, twin rows.

TIME=1 SPACING=1

PLOT OF PCTGRN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PPCTG*DEFOL SYMBOL USED IS *

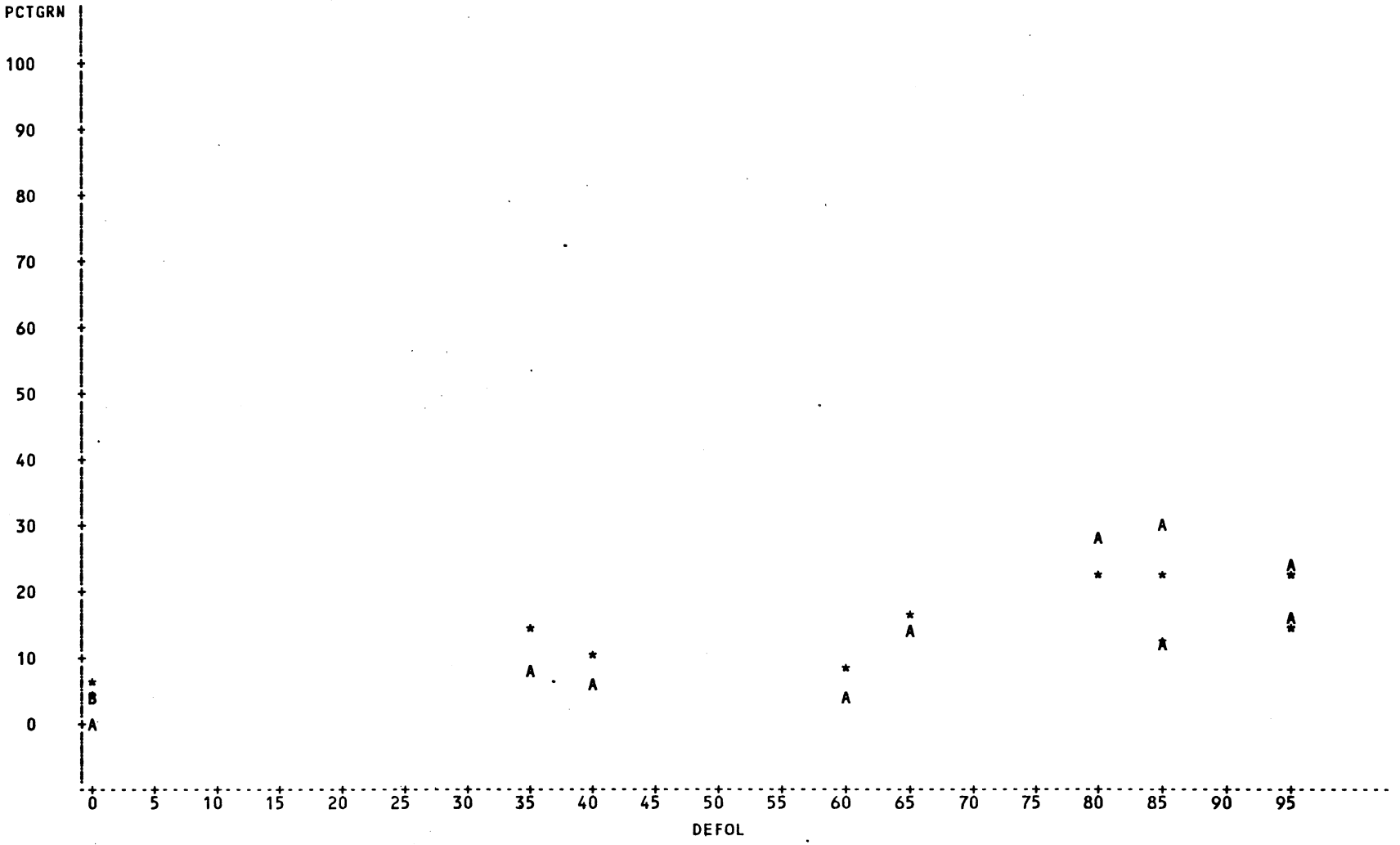


NOTE: 1 OBS HAD MISSING VALUES OR WERE OUT OF RANGE

Fig. 5. Relationship of amount of early hail injury to percentage of green fruit of processing tomatoes - hail treatment 11 days after planting, single rows.

TIME=1 SPACING=2

PLOT OF PCTGRN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PPCTG*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HAD MISSING VALUES OR WERE OUT OF RANGE

Fig. 6. Relationship of amount of early hail injury to percentage of green fruit of processing tomatoes - hail treatment 11 days after planting, twin rows.

B. Simulated Hail--Transplants of Processing Tomatoes

Fruit rots were also very serious in this study because of the extended rainy period in early July. This tends to confuse the results somewhat because hail injured fruits also rotted. Nevertheless, the trends are there and the general effects were similar to the 1986 trial results.

One planting was lost due to very poor plant recovery after transplanting; consequently a fourth planting was made to make up the 3 planting dates for this trial. The above normal temperatures in June and July with above normal rainfall promoted excellent vegetative vigor and extended the bloom period to longer than normal. Also, the plants of the later plantings tended to catch up the earlier plantings.

Planting dates were May 21, June 1 and June 10; variety was Heinz 1810; single and twin rows were used and simulated hail treatments were made on June 29 and July 23. The plant development stages follow.

June 29 Hailing of May 21 Planting (plants 39 days from planting)

Considerable full bloom for major crop set, main stem 2 clusters of fruit with fruits up to 3/4 in. diam., axillary shoots up to 10 inches long with 2-3 clusters in full bloom and some tip clusters with an occasional flower open. NOTE: plants at this stage are not at what is called a snow-ball bloom in which all shoot tip clusters are in bloom and the plant has an overall yellow appearance.

June 29 Hailing of the June 1 Planting (plants 28 days old)

Fruits on first cluster on main stem set and second cluster in bloom; axillary shoots 6-10 inches long with first cluster in bloom and a few flowers opening on second cluster. This would be mid- to late- vegetative growth period.

June 29 Hailing of June 10 Planting (19-day-old plants)

A few flowers open in first cluster of main stem, axillary shoots 2-4 inches long with first cluster buds visible. This would be considered early vegetative growth period.

July 23 Hailing of May 21 Planting (plants 63-days-old)

Major fruit set is over, flowers on tips of shoots are falling and an occasional ripe fruit is present on the first cluster on the main stem. This is in the middle of fruit sizing to makeup yield of crop (weight).

July 23 Hailing of June 1 Planting (plants 52-days-old)

Plants would be considered to be in "snow-ball" bloom with tip clusters in full bloom on all shoots and in some cases the last 2 clusters are in full bloom. Fruits are set on first 2 or 3 clusters of main stem and axillary shoots. Fruits generally half to 3/4 of full size.

July 23 Hailing of June 10 Planting (plants 42-days-old)

Plants in full bloom for major fruit set. Tip 1 or 2 clusters not in bloom. Stage very similar to the May 21 planting on the June 29 hail treatment above.

Data on the relationship of severity of injury as measured by defoliation at the various stages of plant development to yield of ripes, greens, rots and total fruits are summarized in Figures 7 through 30. Since the differences between single- and twin-rows were affected nearly the same by hail treatment, only the single row data are presented. Yields were generally greater from the twin row configuration, but hail effects were similar

1. Hail injury (simulated) causes a reduction in total yield of fruit of transplanted tomatoes; generally the older the plants when injured, the greater the loss in yield; the more severe the injury, the greater the loss in yield.
2. Hail injury generally results in a delay in plant development and thus a delay in maturity; the greater the injury, the greater the delay; generally the earlier in plant development when injury occurred, the greater the influence on delayed maturity. These results were confounded with fruit rots and thus, this picture is not very clear when based upon actual tonnage

yield. If based upon percentage of green fruits, then the delay observations are confirmed (data not presented).

Observations of maturity estimates on replicate 4 which was not harvested to attempt to estimate maturity delay effects indicate that the slight injury had a very minimal effect on maturity; moderate injury delayed maturity from 3 to 5 days from the early treatment of all planting dates, but there was no apparent effect from the second hail treatment; the severe treatment delayed ripening from 7 to 10 days from the first date of treatment, but no delay could be determined from the second date of treatment.

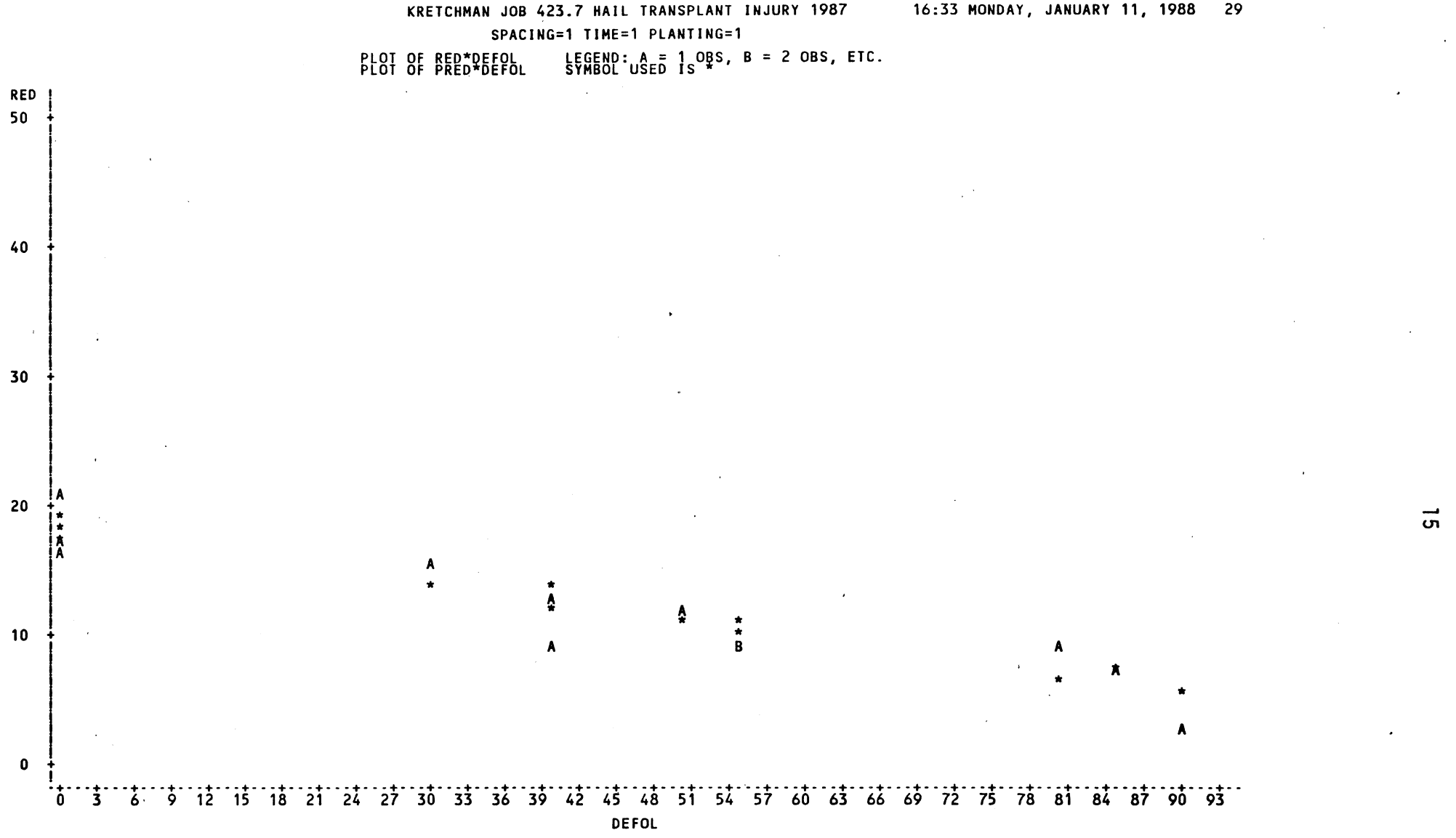
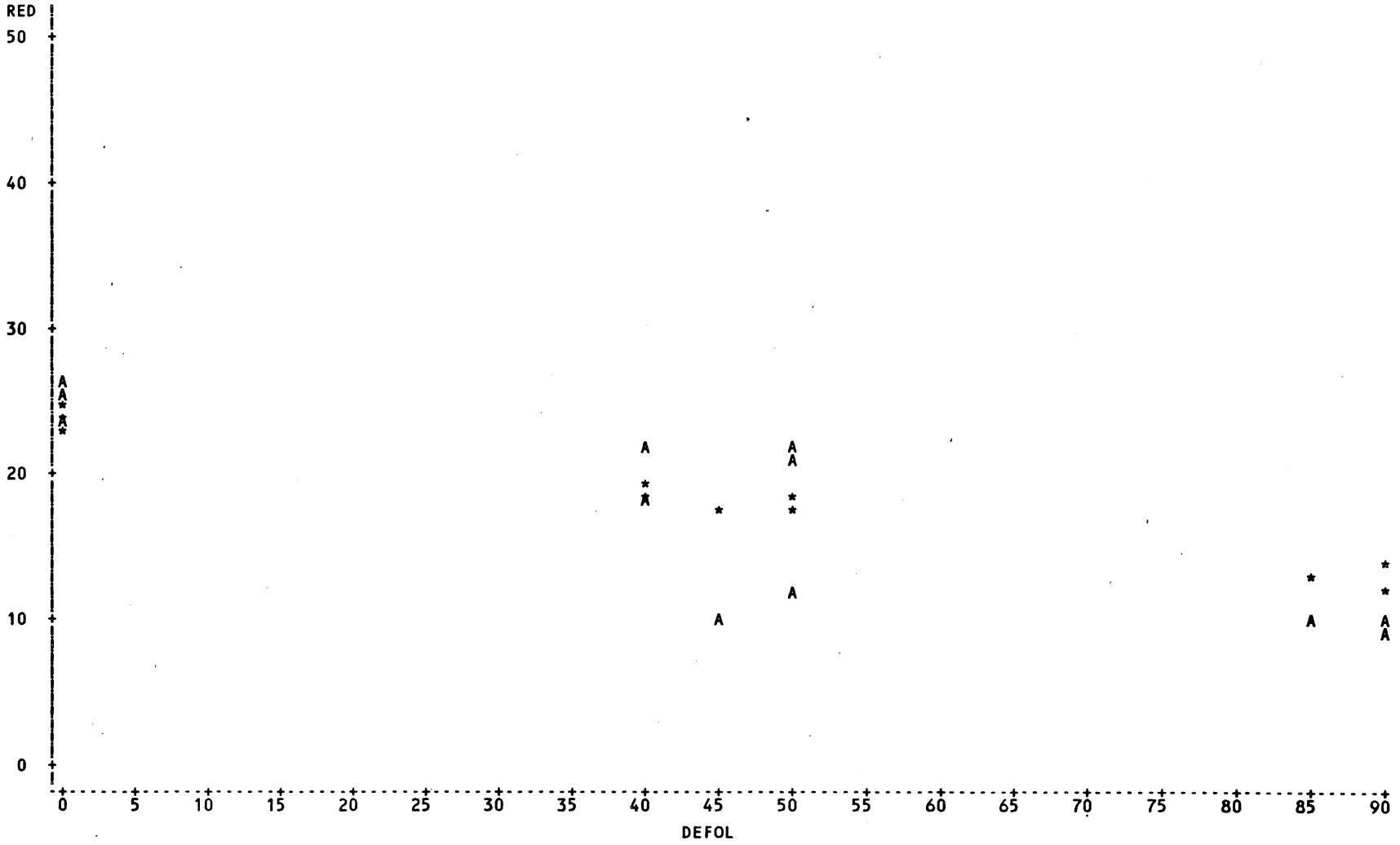


Fig. 7. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 39 days from transplanting (Stage 4) when hail treated on June 29, 1987.

SPACING=1 TIME=1 PLANTING=2

PLOT OF RED*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PRED*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HIDDEN

Fig. 8. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 28 days from transplanting (Stage 3) when hail treated on June 29, 1987.

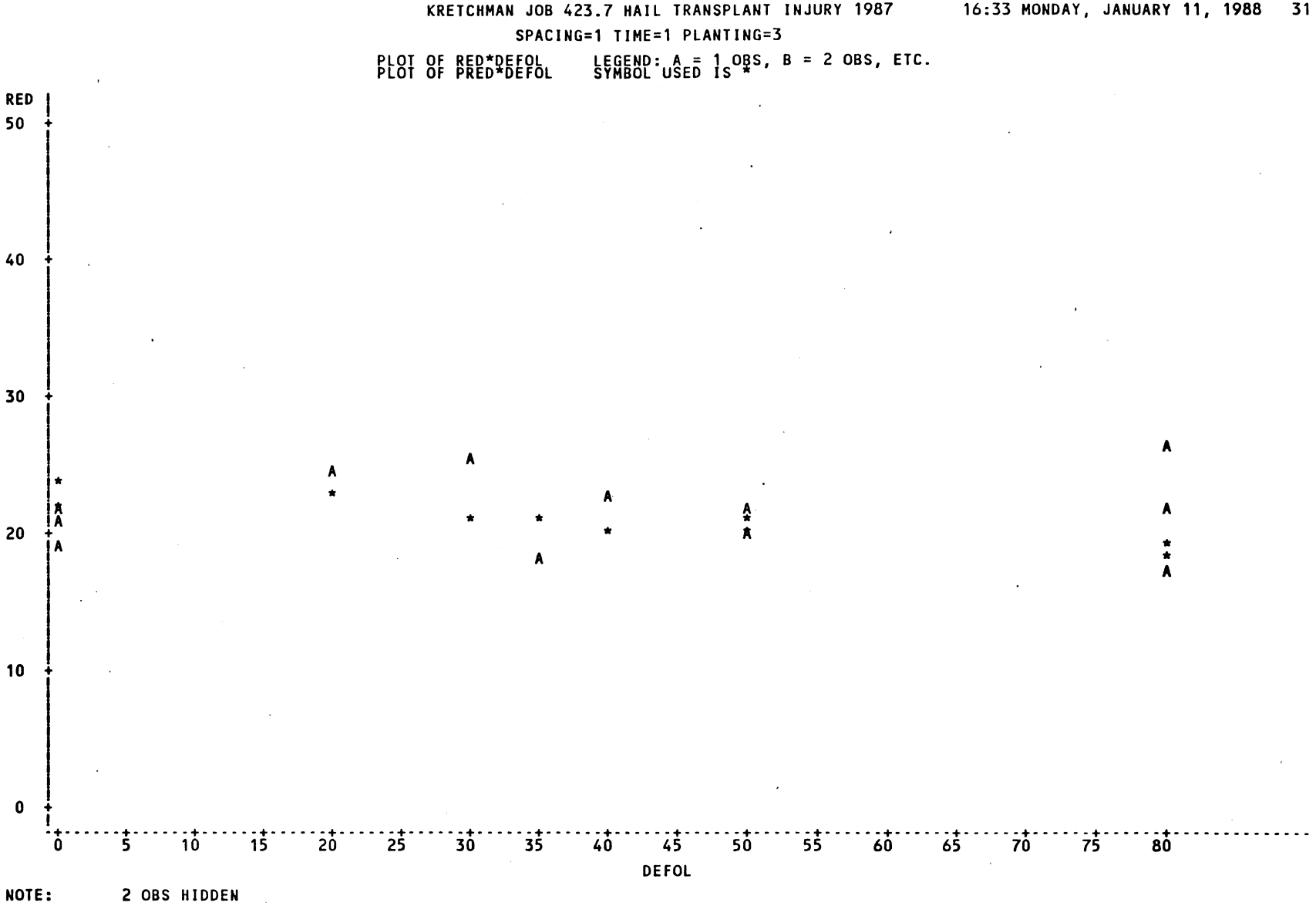


Fig. 9. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 19 days from transplanting (Stage 2) when hail treated on June 29, 1987.

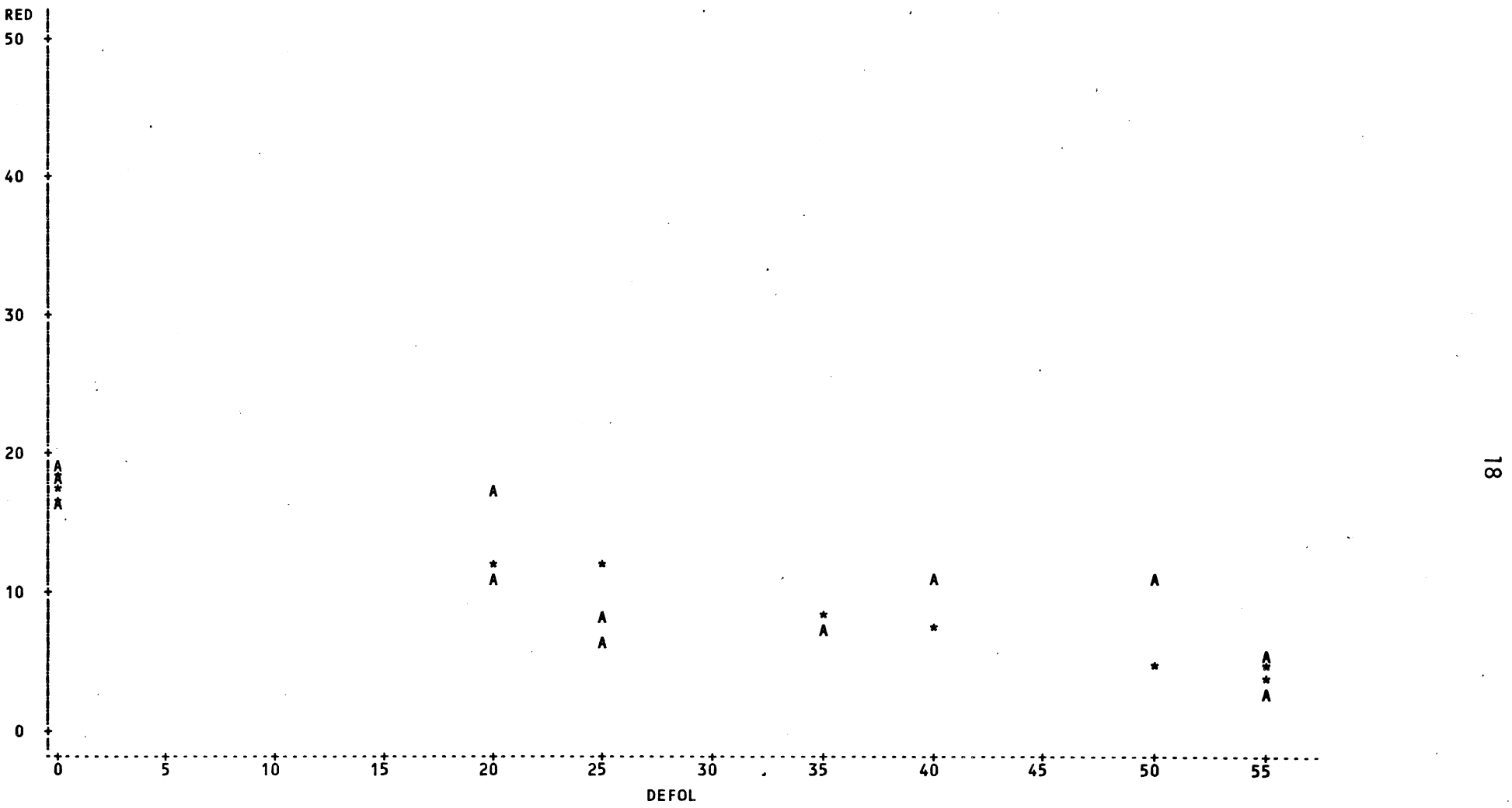


Fig. 10. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 63 days from transplanting (Stage 6.5) when hail treated on July 23, 1987.

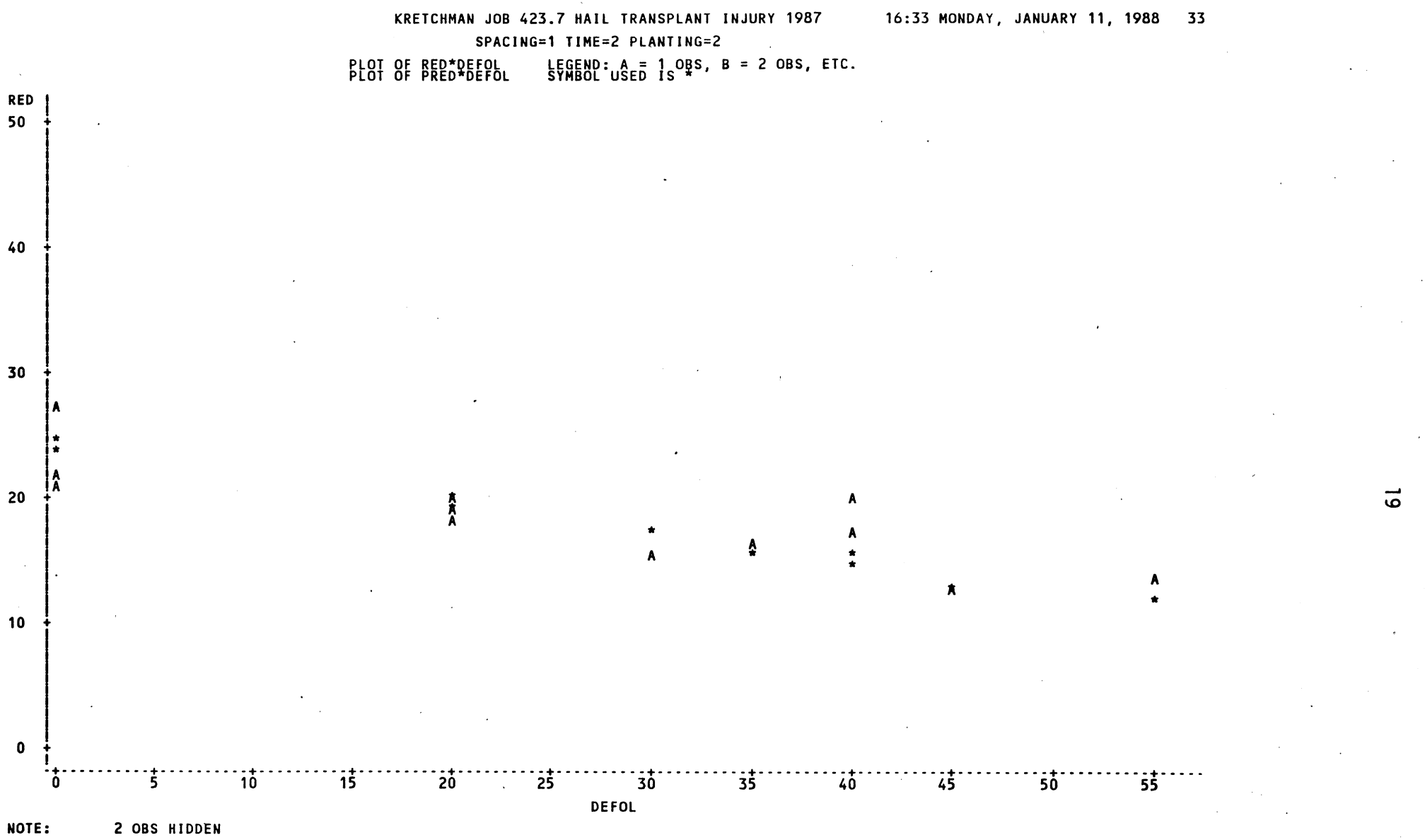


Fig. 11. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 52 days from transplanting (Stage 5) when hail treated on July 23, 1987.

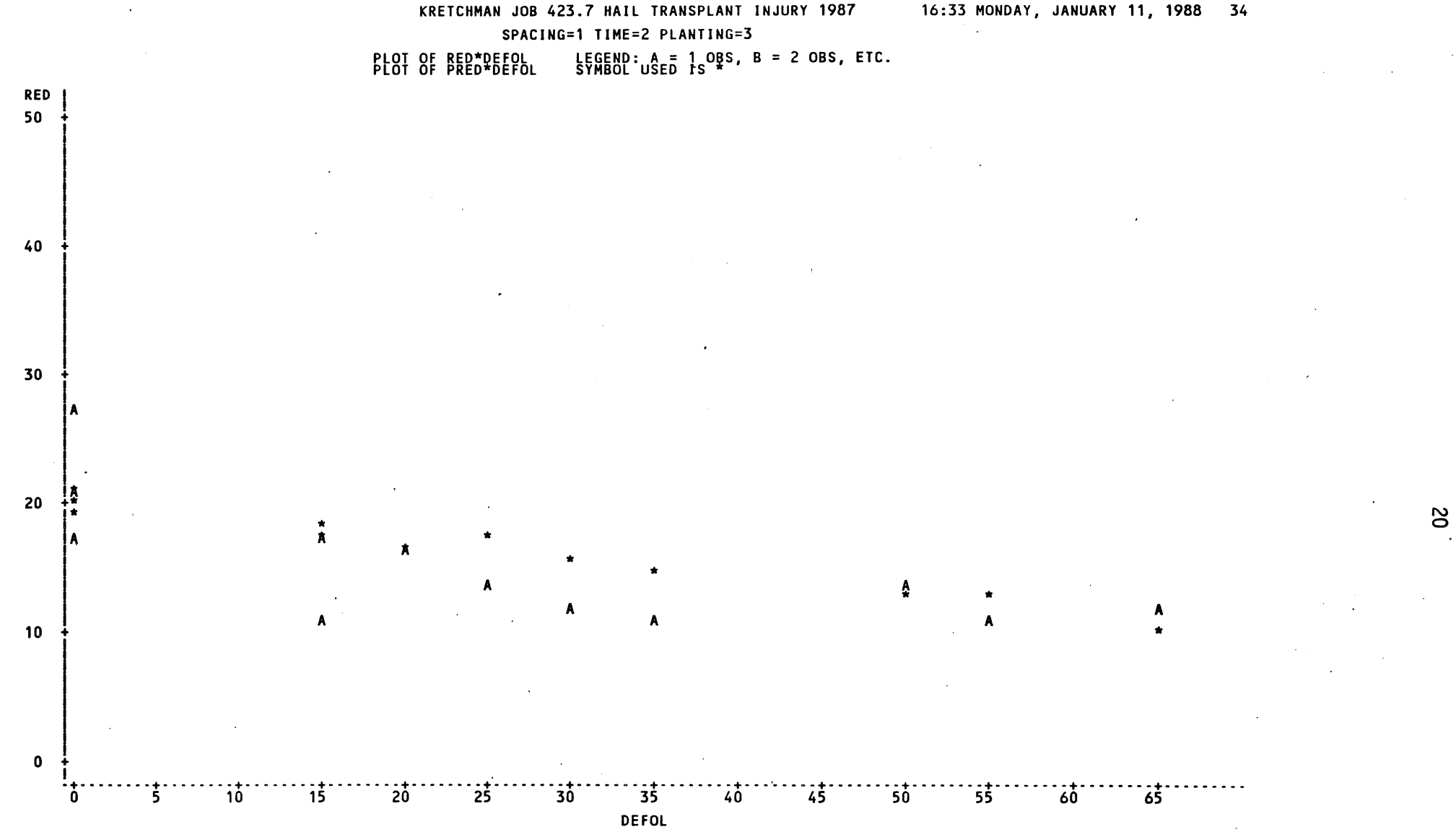


Fig. 12. Relationship of amount of defoliation from hail injury to yield of ripe processing tomatoes. Plants were 42 days from transplanting (Stage 4) when hail treated on July 23, 1987.

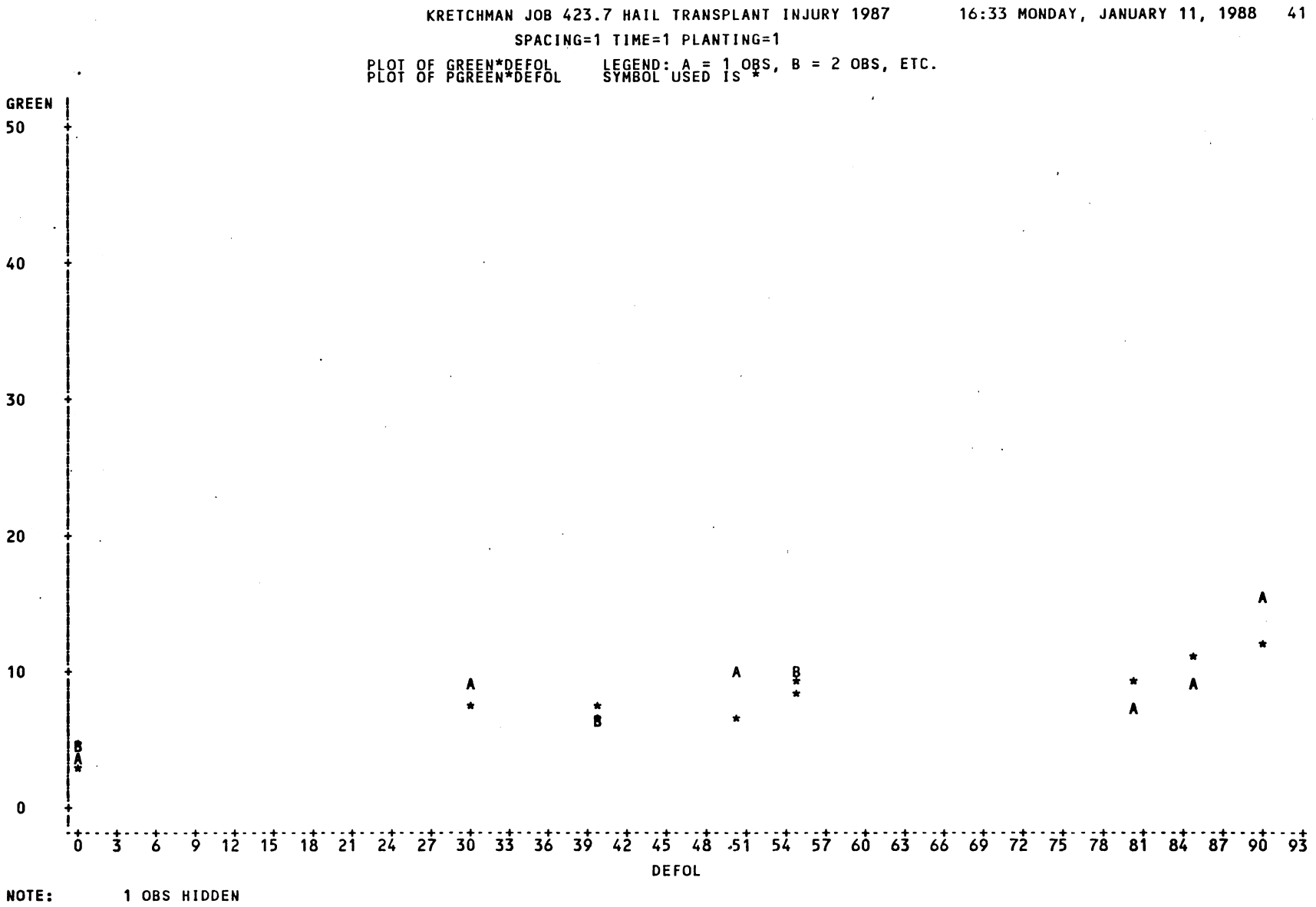


Fig. 13. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 39 days from transplanting (Stage 4) when hail treated on June 29, 1987.

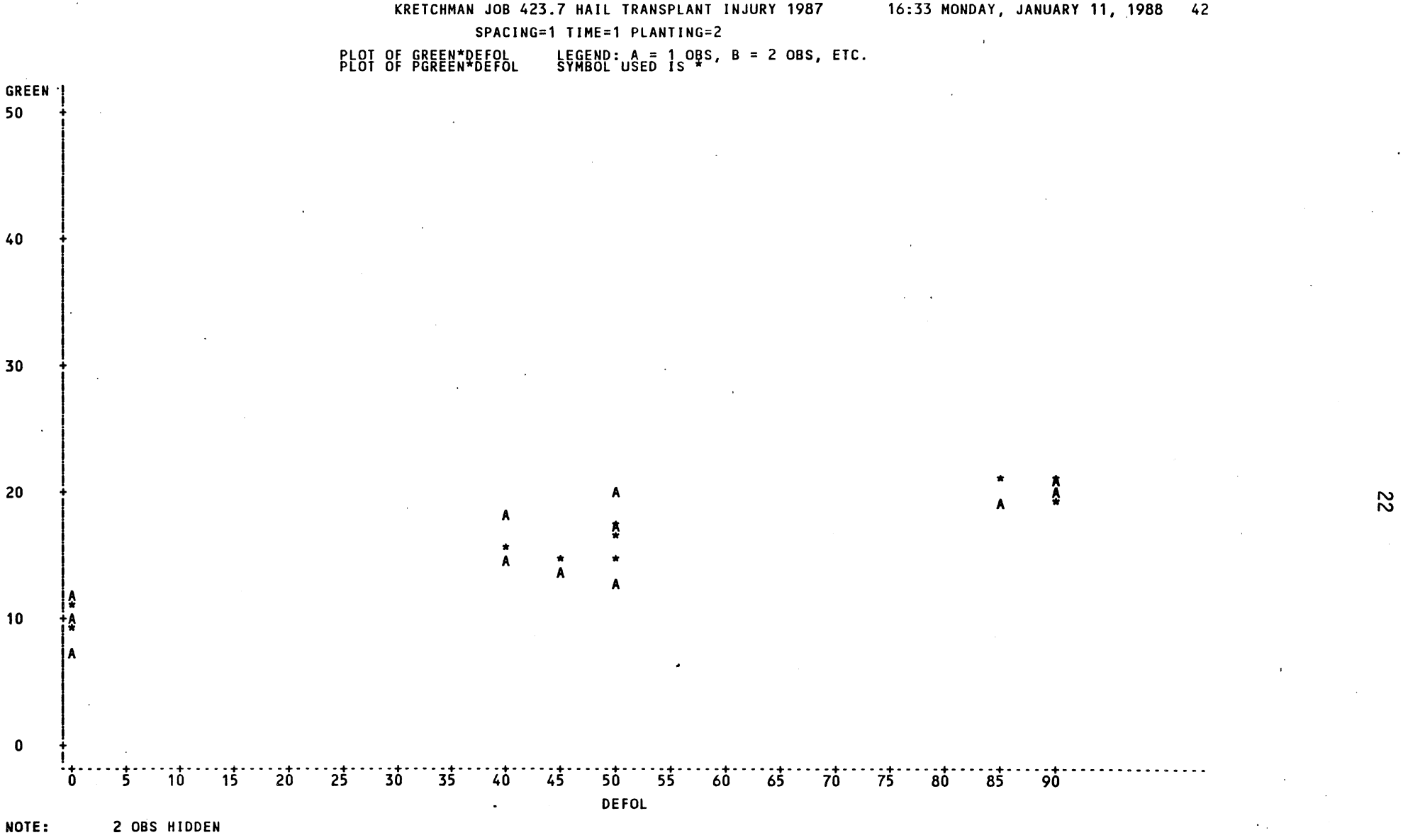
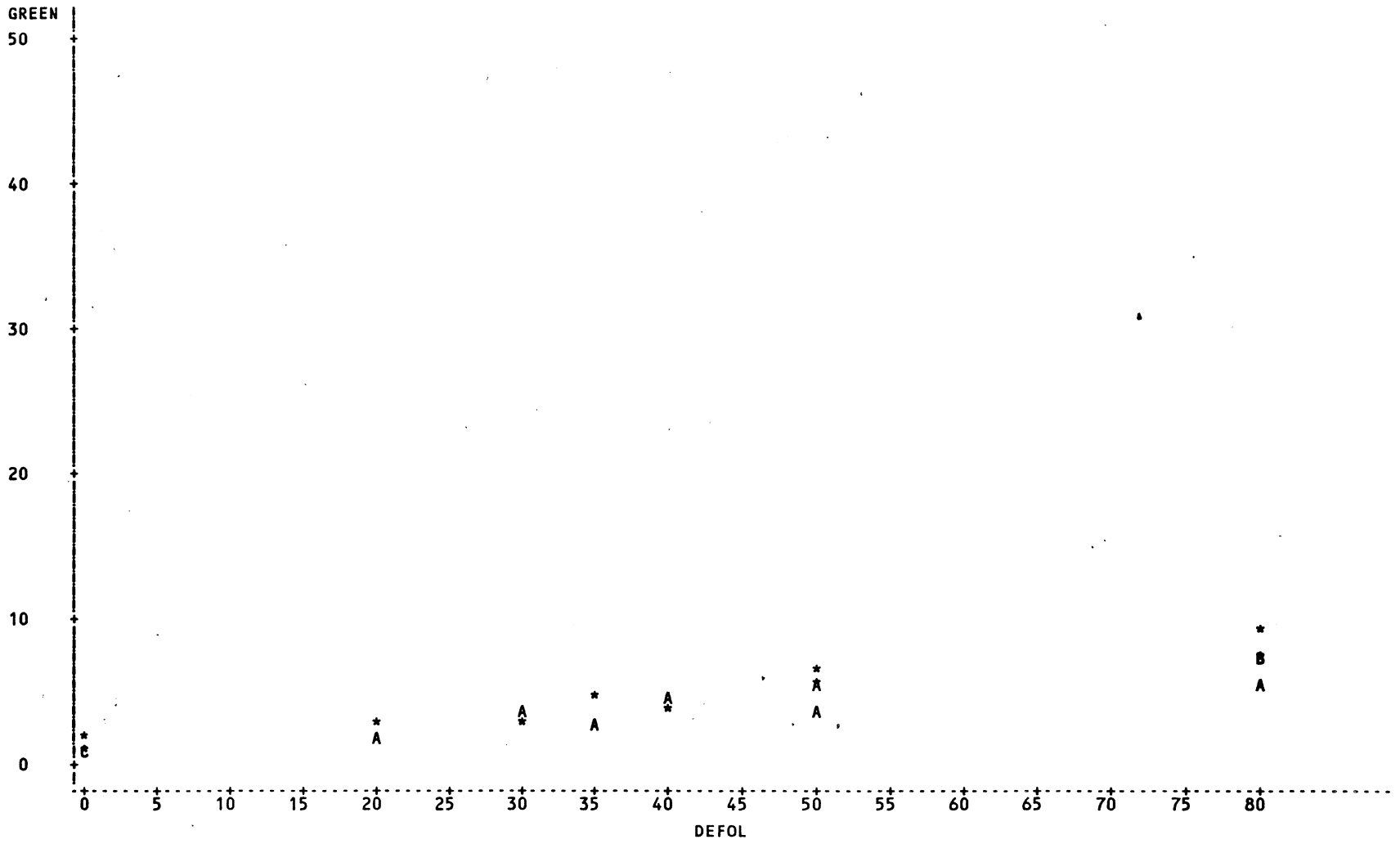


Fig. 14. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 28 days from transplanting (Stage 3) when hail treated on June 29, 1987.

SPACING=1 TIME=1 PLANTING=3

PLOT OF GREEN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PGREEN*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HAD MISSING VALUES OR WERE OUT OF RANGE 1 OBS HIDDEN

Fig. 15. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 19 days from transplanting (Stage 2) when hail treated on June 29, 1987.

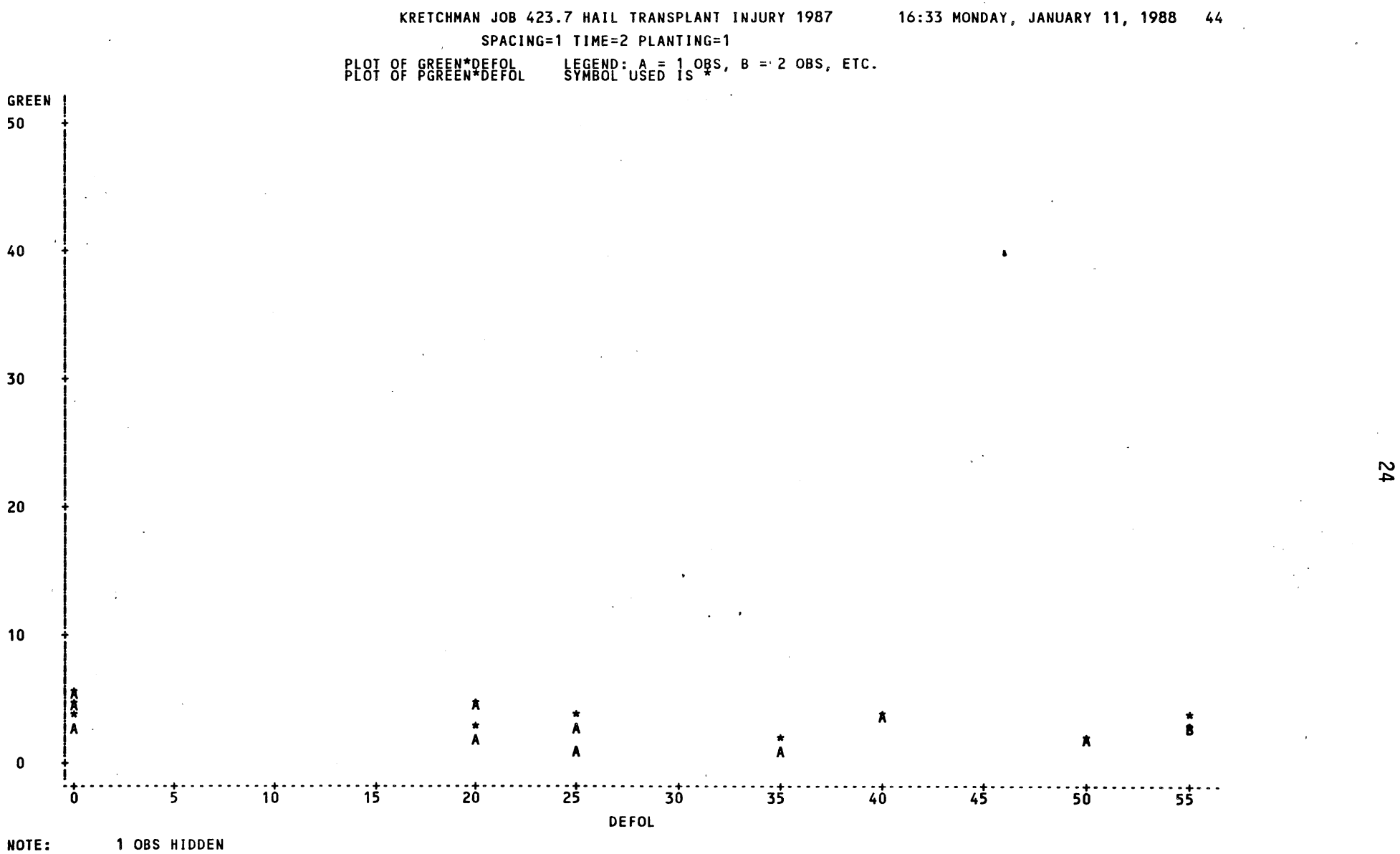
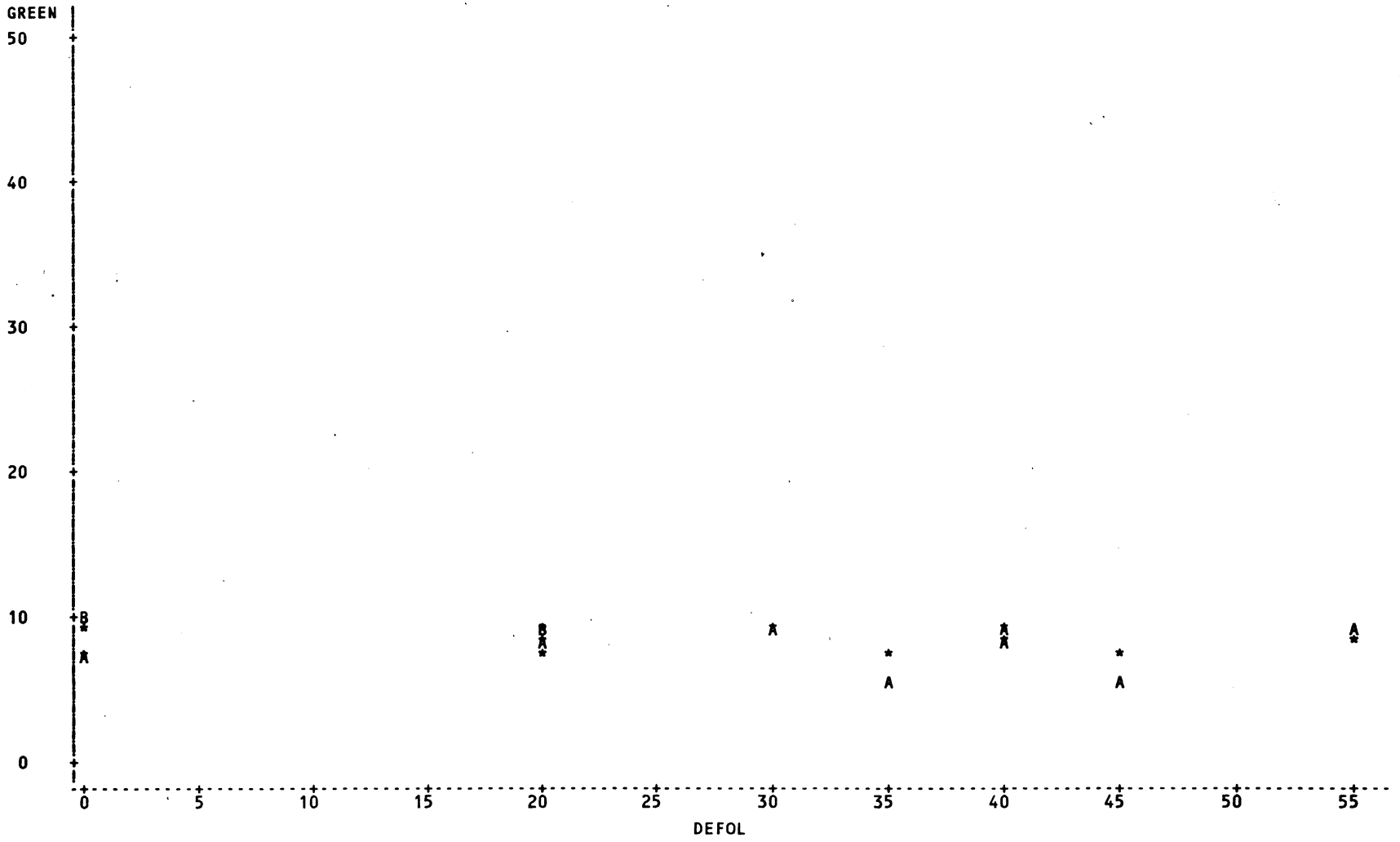


Fig. 16. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 63 days from transplanting (Stage 6.5) when hail treated on July 23, 1987.

SPACING=1 TIME=2 PLANTING=2

PLOT OF GREEN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PGREEN*DEFOL SYMBOL USED IS *

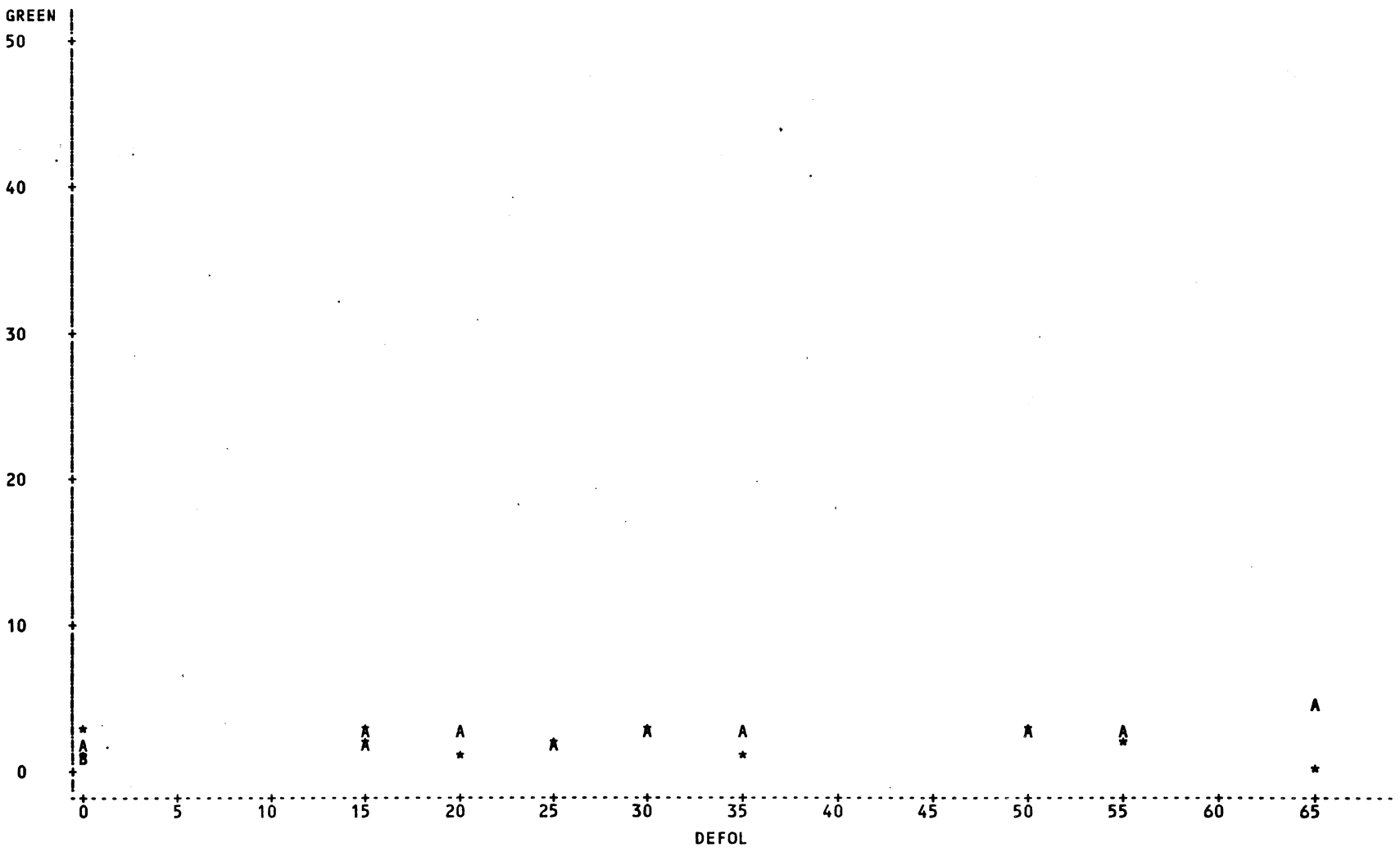


NOTE: 1 OBS HIDDEN

Fig. 17. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 52 days from transplanting (Stage 5) when hail treated on July 23, 1987.

SPACING=1 TIME=2 PLANTING=3

PLOT OF GREEN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PGREEN*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HIDDEN

Fig. 18. Relationship of amount of defoliation from hail injury to yield of green processing tomatoes. Plants were 42 days from transplanting (Stage 4) when hail treated on July 23, 1987.

SPACING=1 TIME=1 PLANTING=1

PLOT OF ROT*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PROT*DEFOL SYMBOL USED IS *

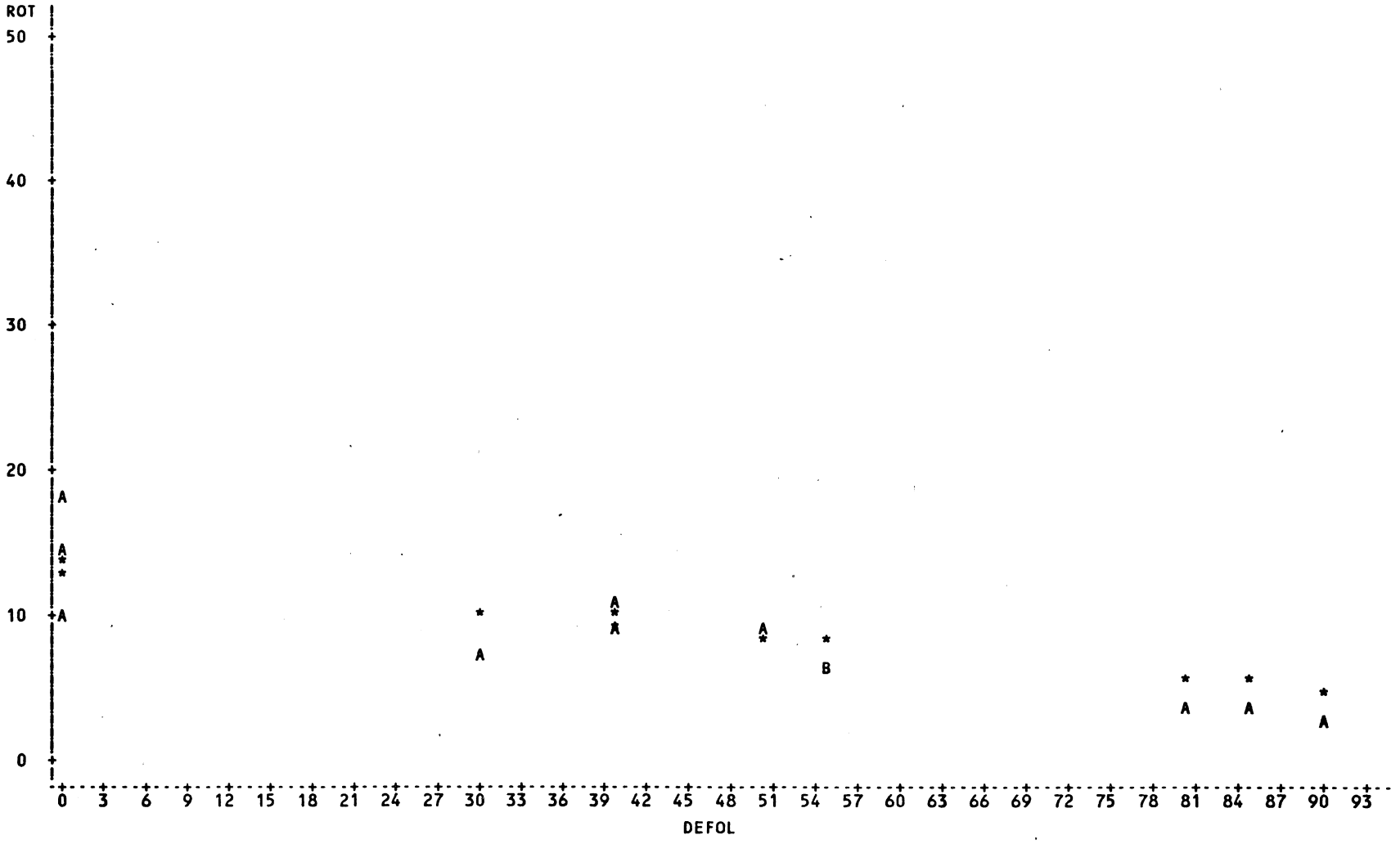
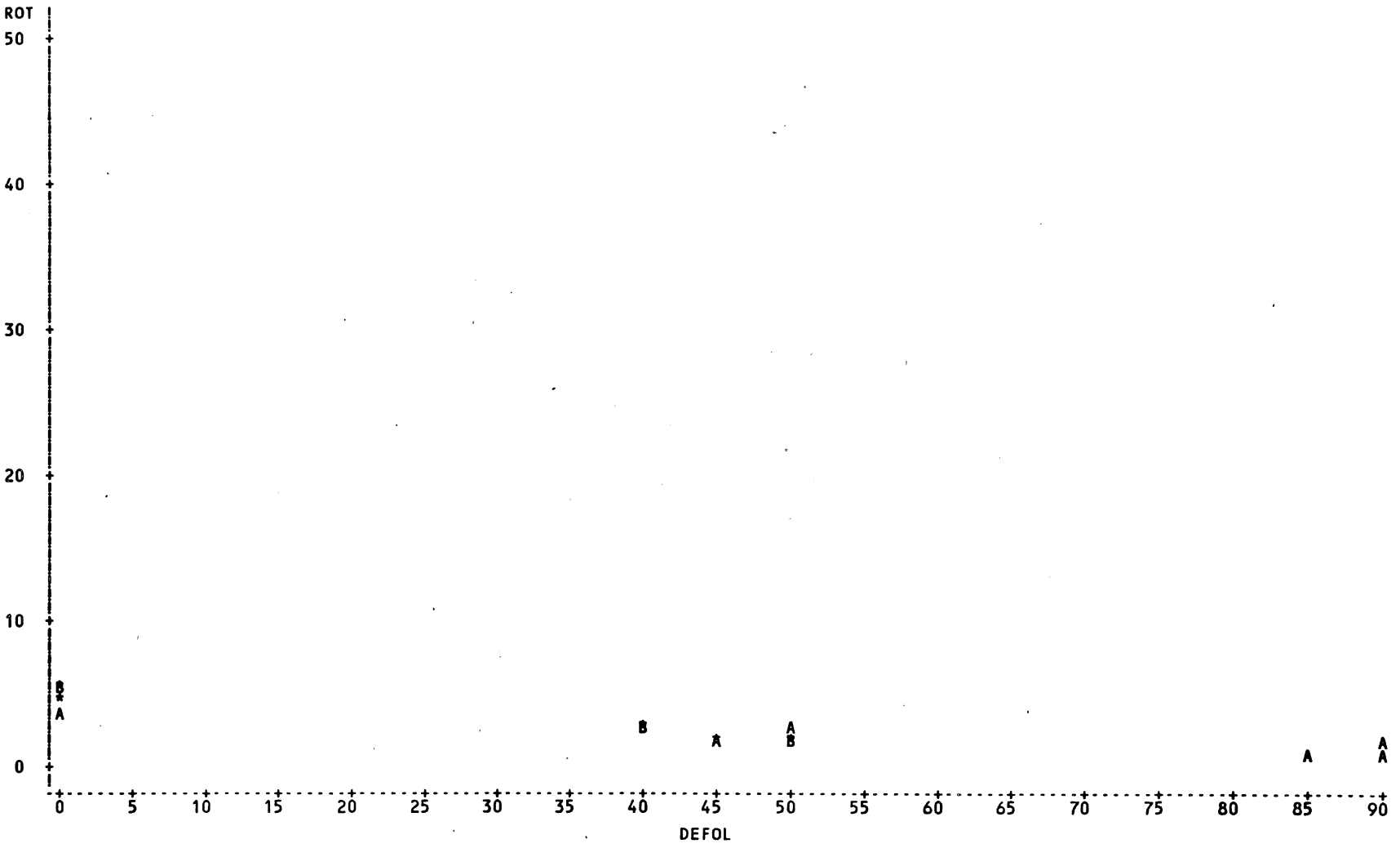


Fig. 19. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 39 days from transplanting (Stage 4) when hail treated on June 29, 1987.

SPACING=1 TIME=1 PLANTING=2

PLOT OF ROT*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PROT*DEFOL SYMBOL USED IS *



NOTE: 3 OBS HAD MISSING VALUES OR WERE OUT OF RANGE 4 OBS HIDDEN

Fig. 20. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 28 days from transplanting (Stage 3) when hail treated on June 29, 1987.

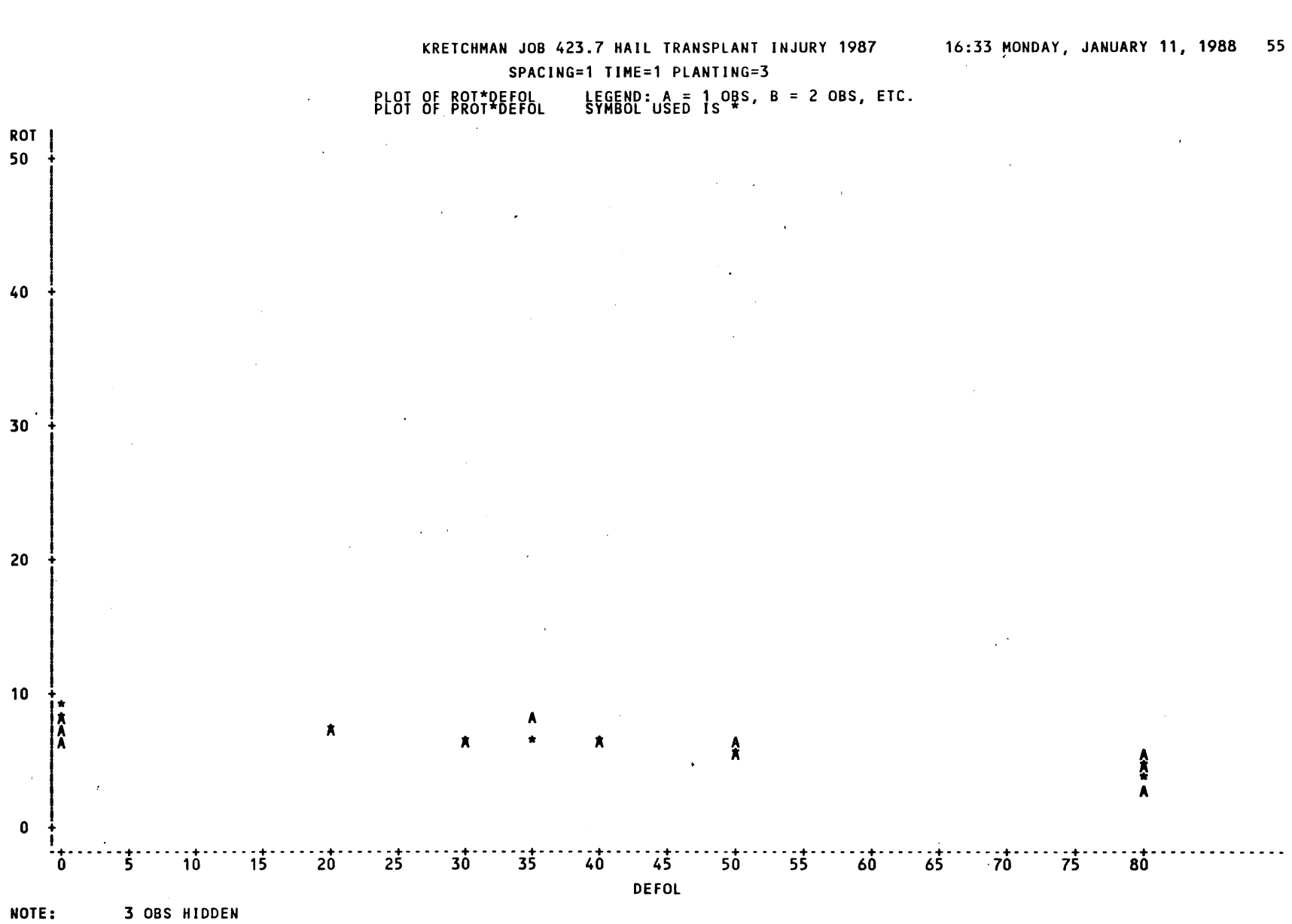
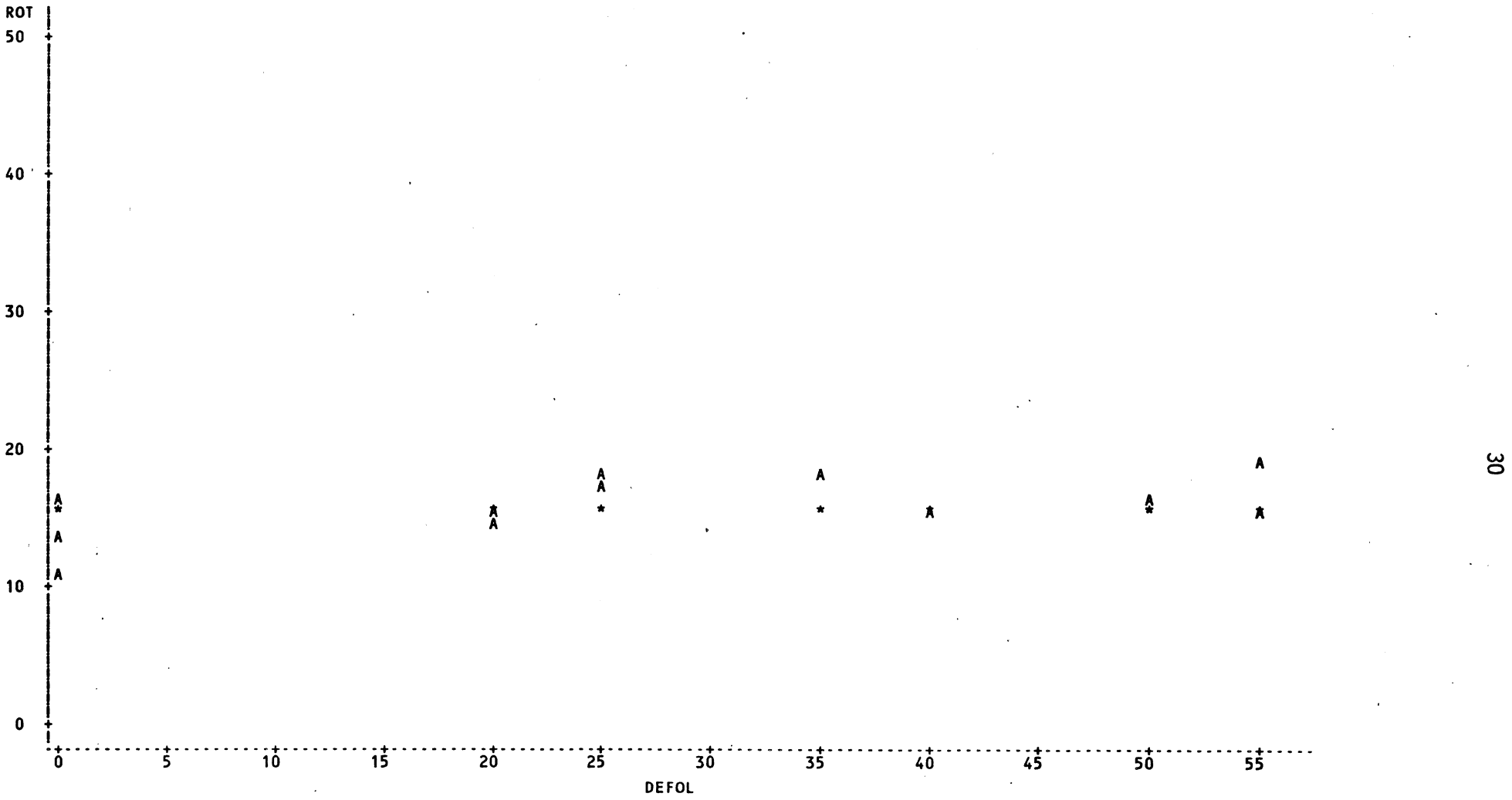


Fig. 21. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 19 days from transplanting (Stage 2) when hail treated on June 29, 1987.

SPACING=1 TIME=2 PLANTING=1

PLOT OF ROT*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PROT*DEFOL SYMBOL USED IS *



NOTE: 5 OBS HIDDEN

Fig. 22. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 63 days from transplanting (Stage 6.5) when hail treated on July 23, 1987.

SPACING=1 TIME=2 PLANTING=2

PLOT OF ROT*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PROT*DEFOL SYMBOL USED IS *

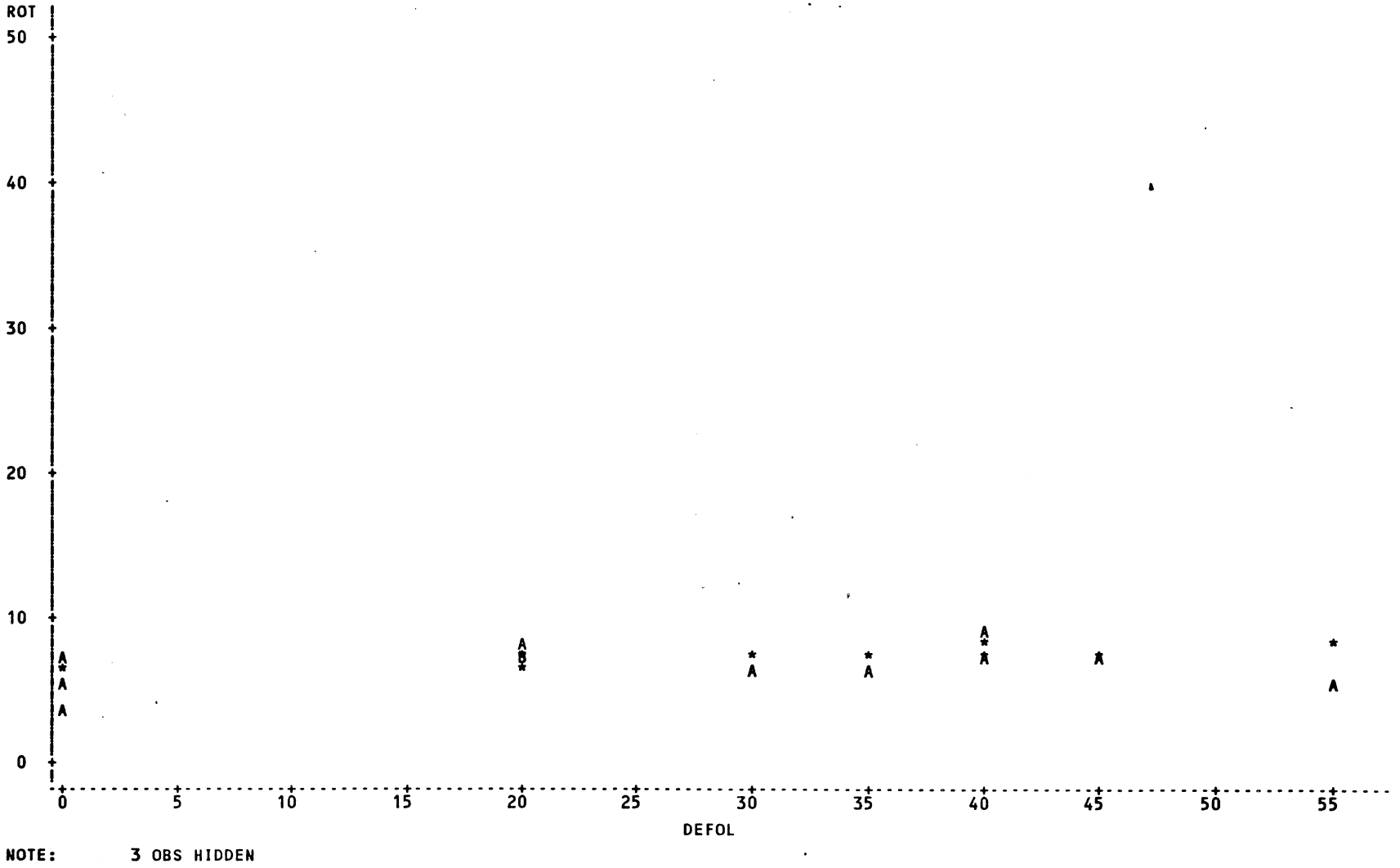


Fig. 23. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 52 days from transplanting (Stage 5) when hail treated on July 23, 1987.

SPACING=1 TIME=2 PLANTING=3

PLOT OF ROT*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PROT*DEFOL SYMBOL USED IS *

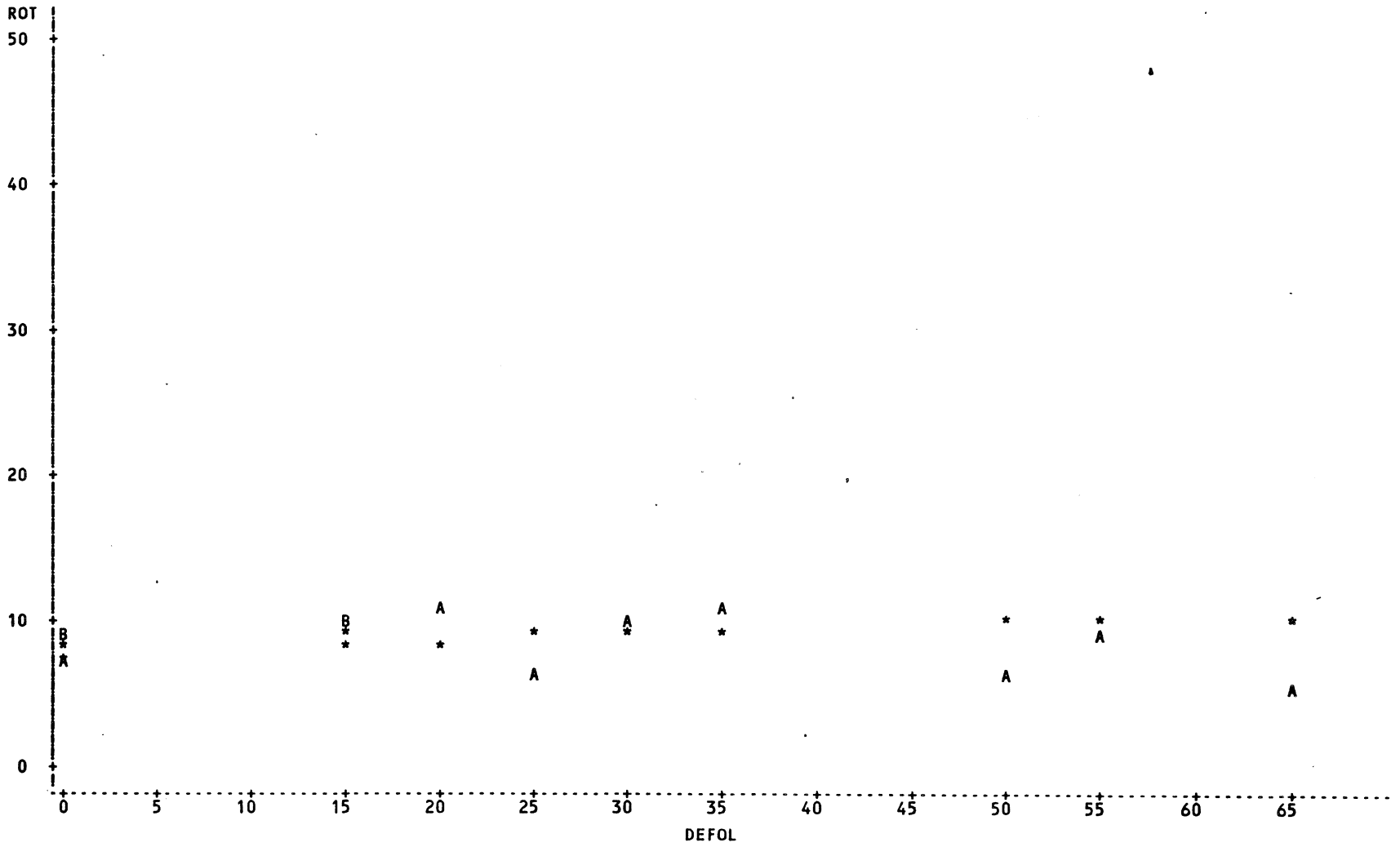


Fig. 24. Relationship of amount of defoliation from hail injury to yield of rotted processing tomatoes. Plants were 42 days from transplanting (Stage 4) when hail treated on July 23, 1987.

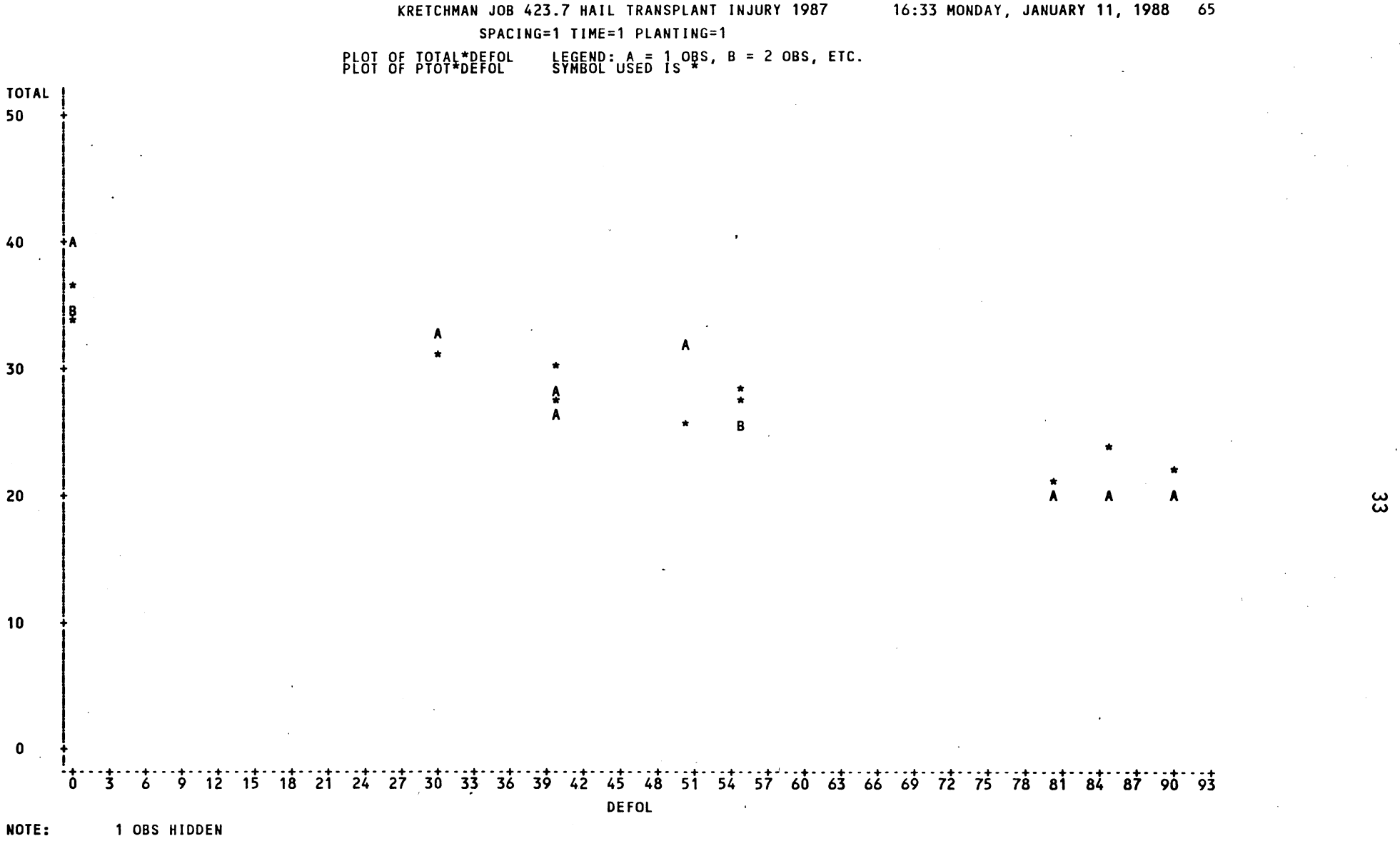


Fig. 25. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 39 days from transplanting (Stage 4) when hail treated on June 29, 1987.

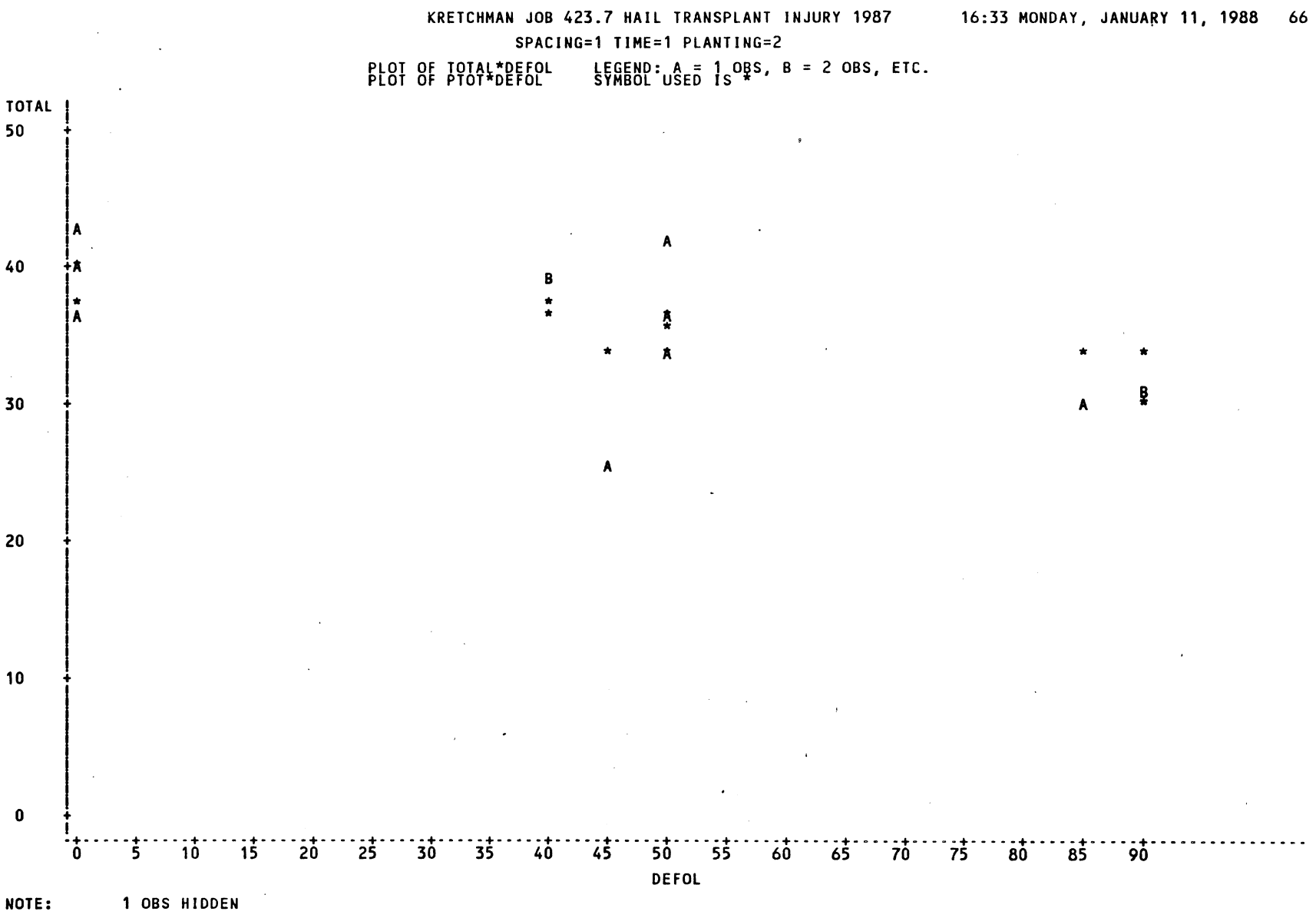


Fig. 26. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 28 days from transplanting (Stage 3) when hail treated on June 29, 1987.

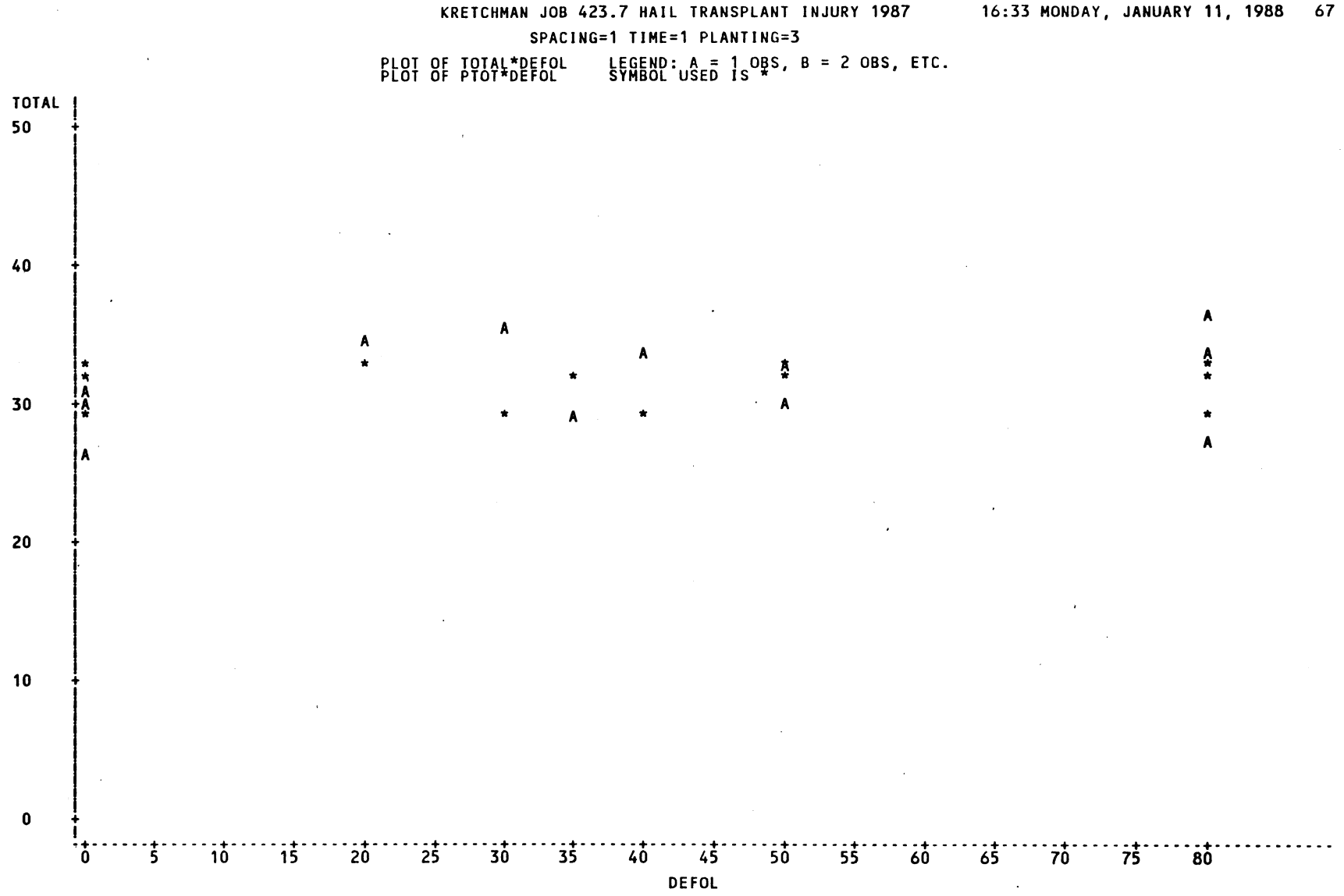


Fig. 27. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 19 days from transplanting (Stage 2) when hail treated on June 29, 1987.

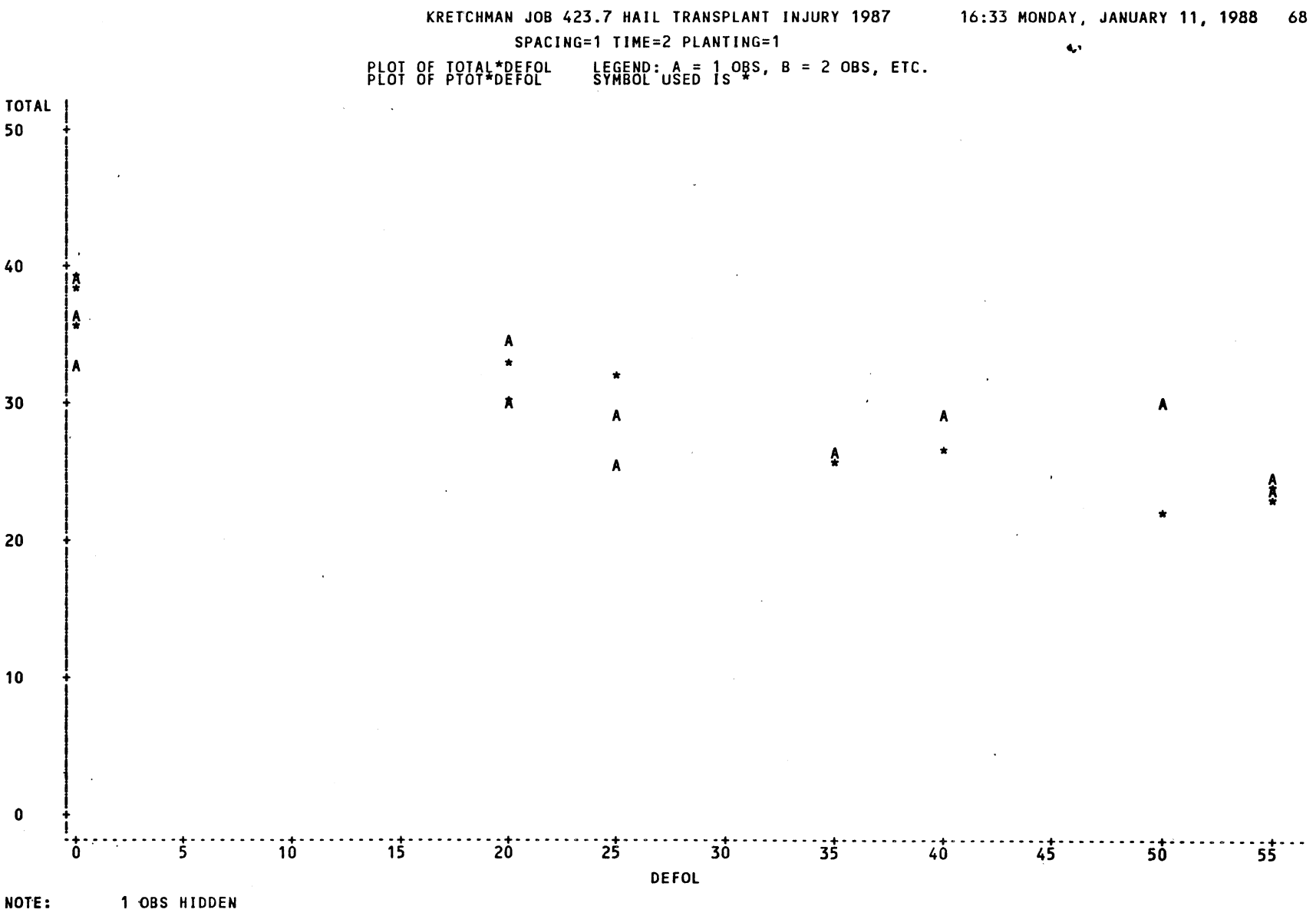


Fig. 28. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 63 days from transplanting (Stage 6.5) when hail treated on July 23, 1987.

SPACING=1 TIME=2 PLANTING=2

PLOT OF TOTAL*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PTOT*DEFOL SYMBOL USED IS *

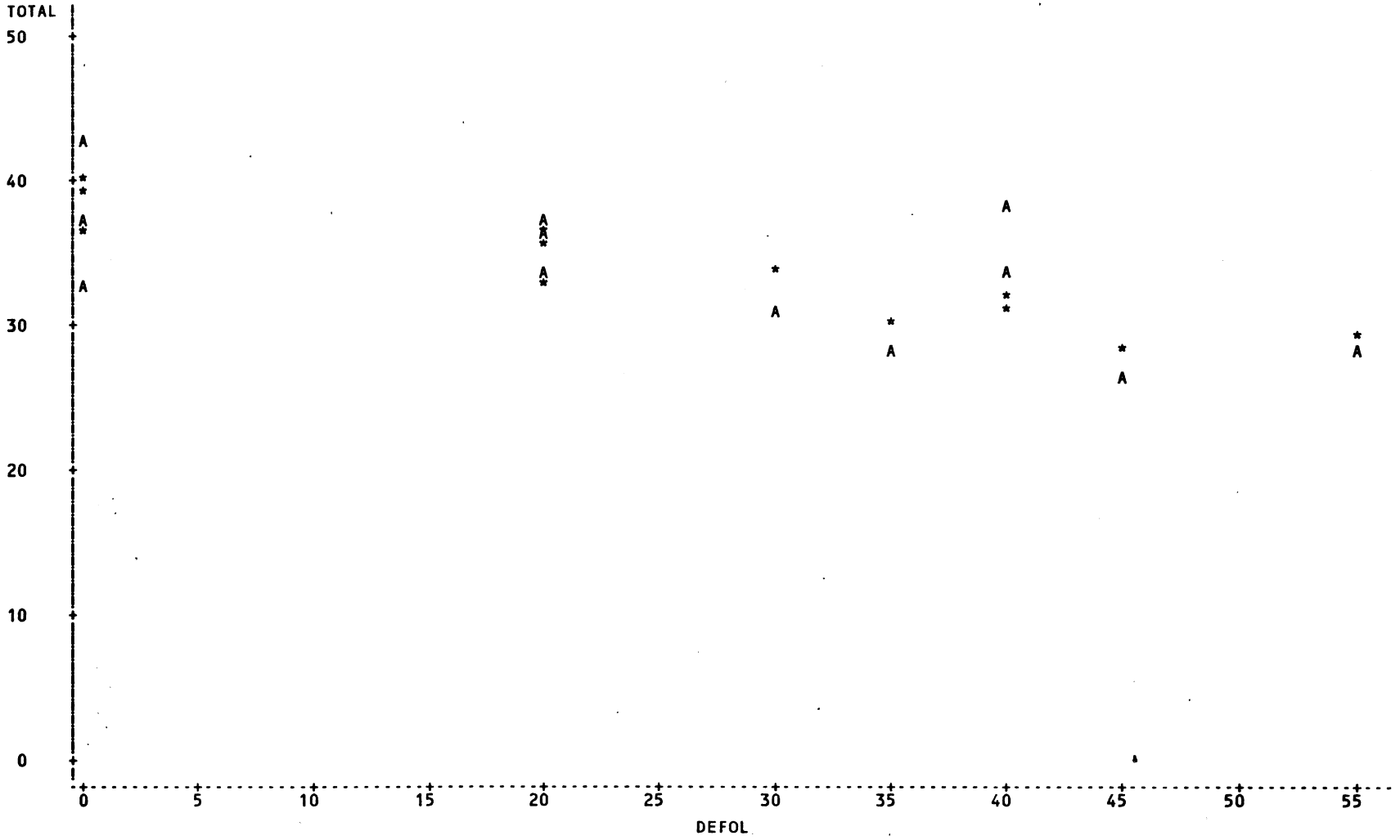


Fig. 29. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 52 days from transplanting (Stage 5) when hail treated on July 23, 1987.

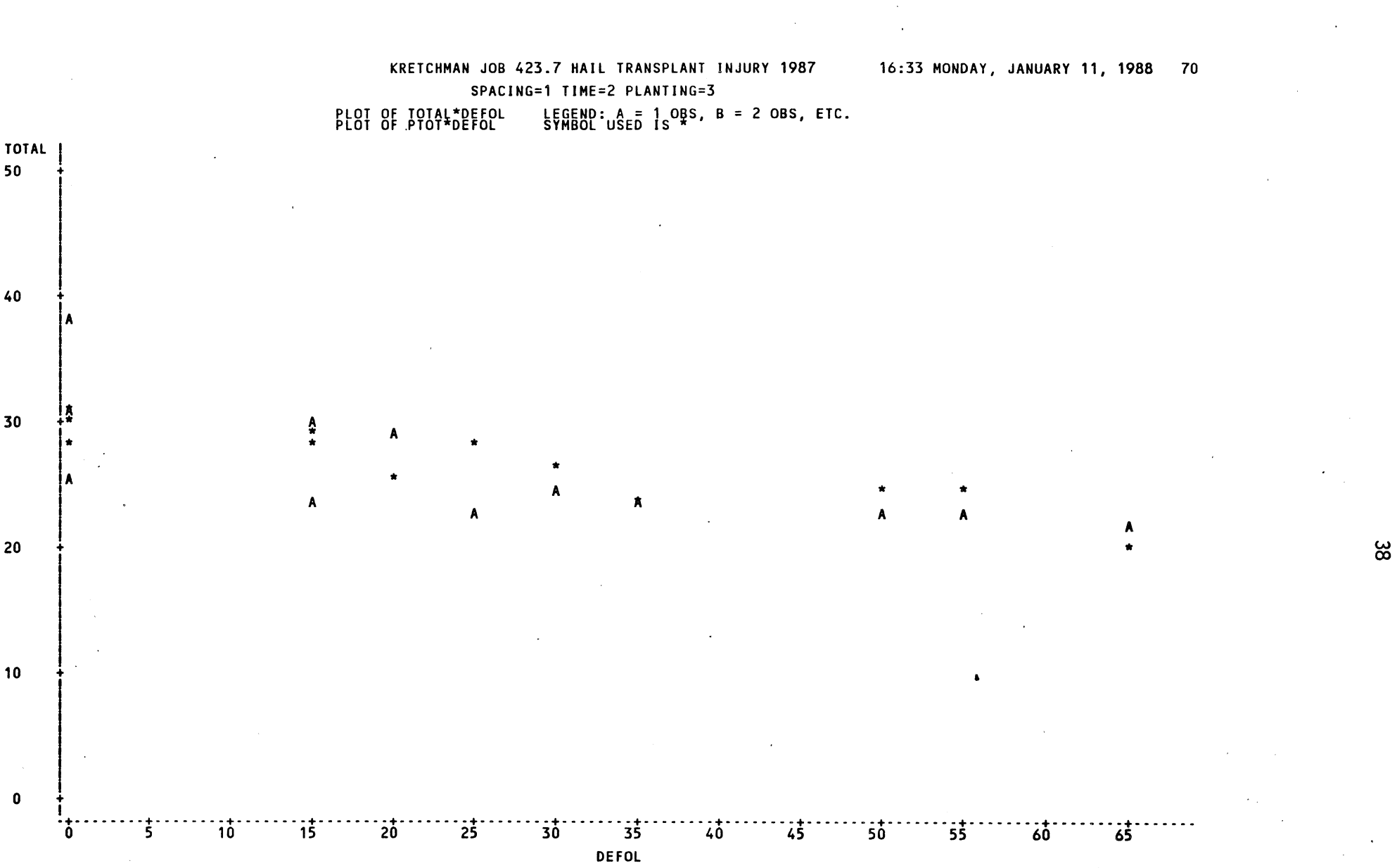


Fig. 30. Relationship of amount of defoliation from hail injury to total yield of tomatoes. Plants were 42 days from transplanting (Stage 4) when hail treated on July 23, 1987.

C. Simulated Hail - Field Seeded

Rains greatly disrupted applying the scheduled treatments in this study. Treatments were scheduled for mid-June, mid-July and mid-August, but the first treatments was on July 10 and the second on August 13. Plants on July 10 were 12-24 inches tall. There were 3 to 5 plants per clump and some plants were larger than others within each clump. The plants had some open flowers on about 50% of the clusters, but this time was at the later stages of vegetative growth and early blossom. Plants had less than 5% of fruit showing color on the August 13 treatment. All fruits had set for the crop, although some late flowers were still in bloom. The vines had broken down to expose the inner fruits and plant stems.

As in 1986, the direct seeded plants were difficult to injure because of the limber, whippy nature of the plants. Injury from the July 10 treatment ranged up to 75% defoliation and up to 45% defoliation from the severe treatment on August 13.

Yield results revealed that the July 10 hail injury treatments only slightly reduced ripe fruit yields and slightly increased green fruit yields (Figs. 31 & 32), but had no apparent influence on total yields (Fig. 33). The August 10 treatments did result in reduced ripe fruit yields (Fig. 34), no effect on green fruit yield (maturity) (Fig. 35), slightly increased fruit rots (Fig. 36) and total yields were reduced (Fig. 37).

D. Plant Development for Staging

Tomato transplants at Wooster suffered from poor survival due to poor plant quality and high temperatures, and some excess rainfall. Nevertheless, some useful data were obtained to help establish some data for a suggested staging of processing tomato transplants.

Staging of field seeded plants is in some respects much simpler and in others, more complex. The plants normally form a single, unbranched stem and usually 2 or 3 flower clusters. However, the number of seedlings in each clump of plants

significantly influences the type of plant development and the number of flower clusters that will form. Single plants react similar to transplanted plants, but still have much less branching. Multiple plants per hill or clump act as a "single" plant with many "stems" depending upon the number of seedlings per hill. Generally these plants have much longer stems than branches on transplanted plants and usually do not exhibit a "snow-ball" bloom. The plant stems can become very prostrate as fruits near the top of the plants begin to size.

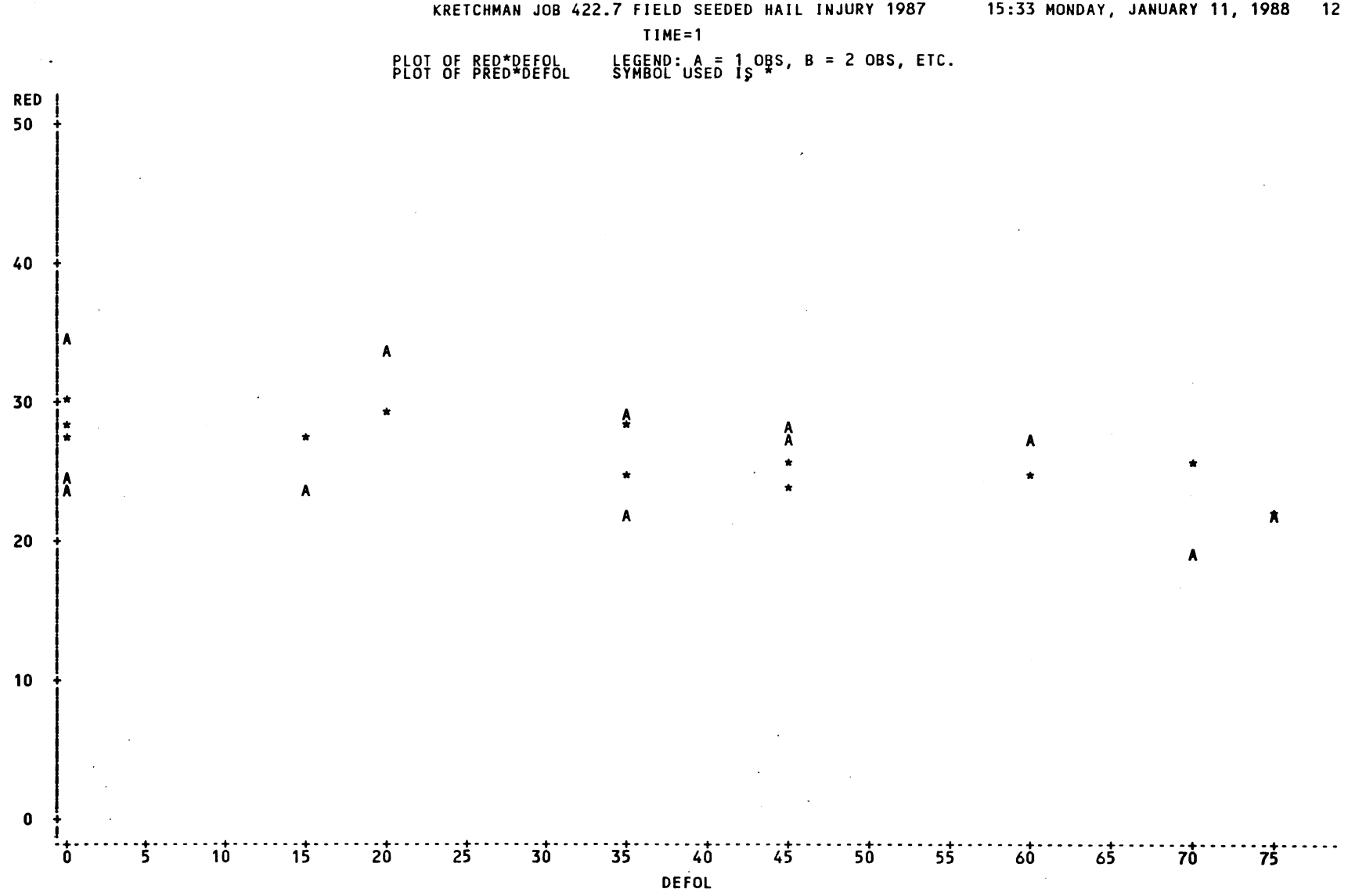
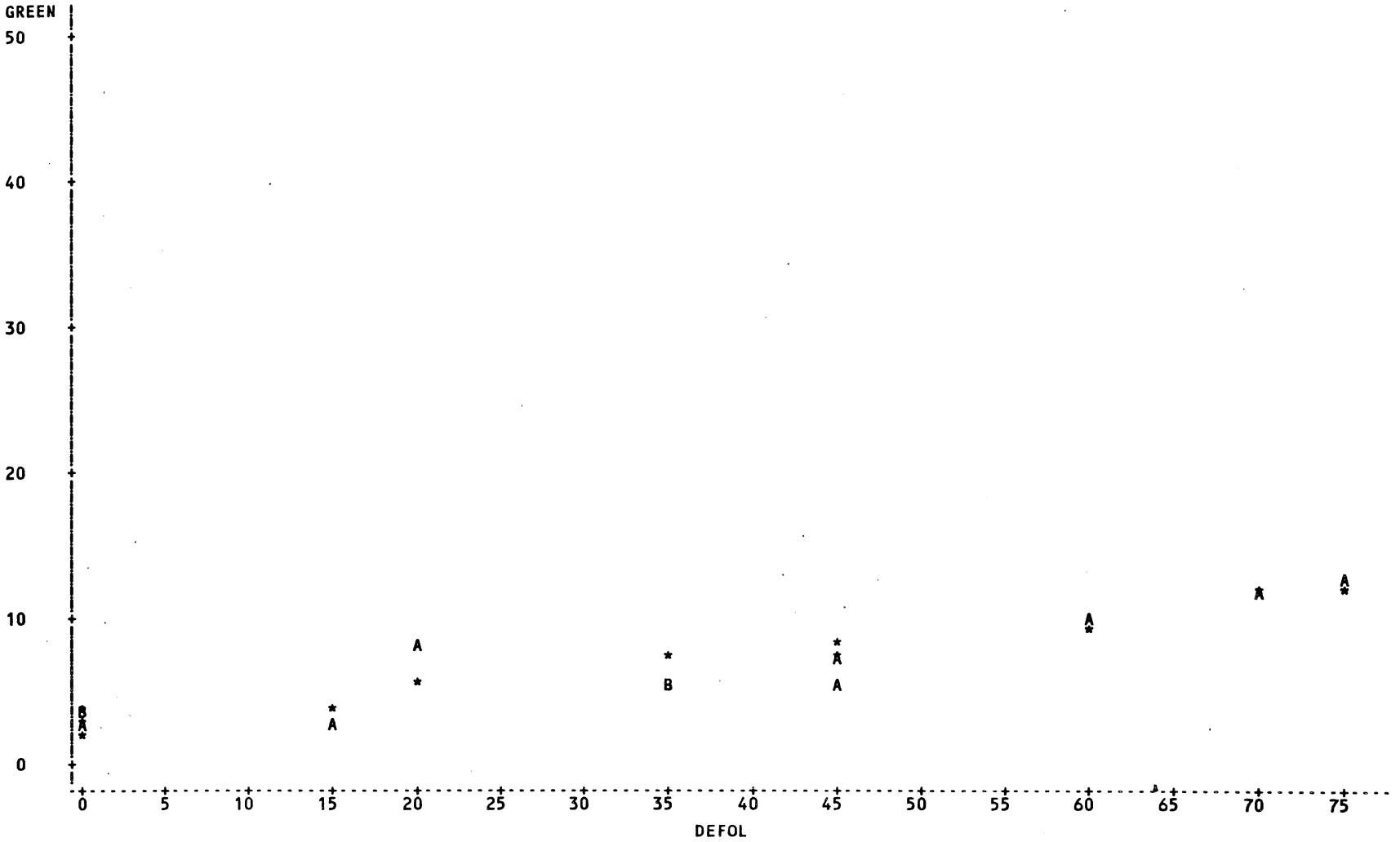


Fig. 31. Relationship of amount of defoliation from hail injury to ripe fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on July 10.

TIME=1

PLOT OF GREEN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PGREEN*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HIDDEN

Fig. 32. Relationship of amount of defoliation from hail injury to green fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on July 10.

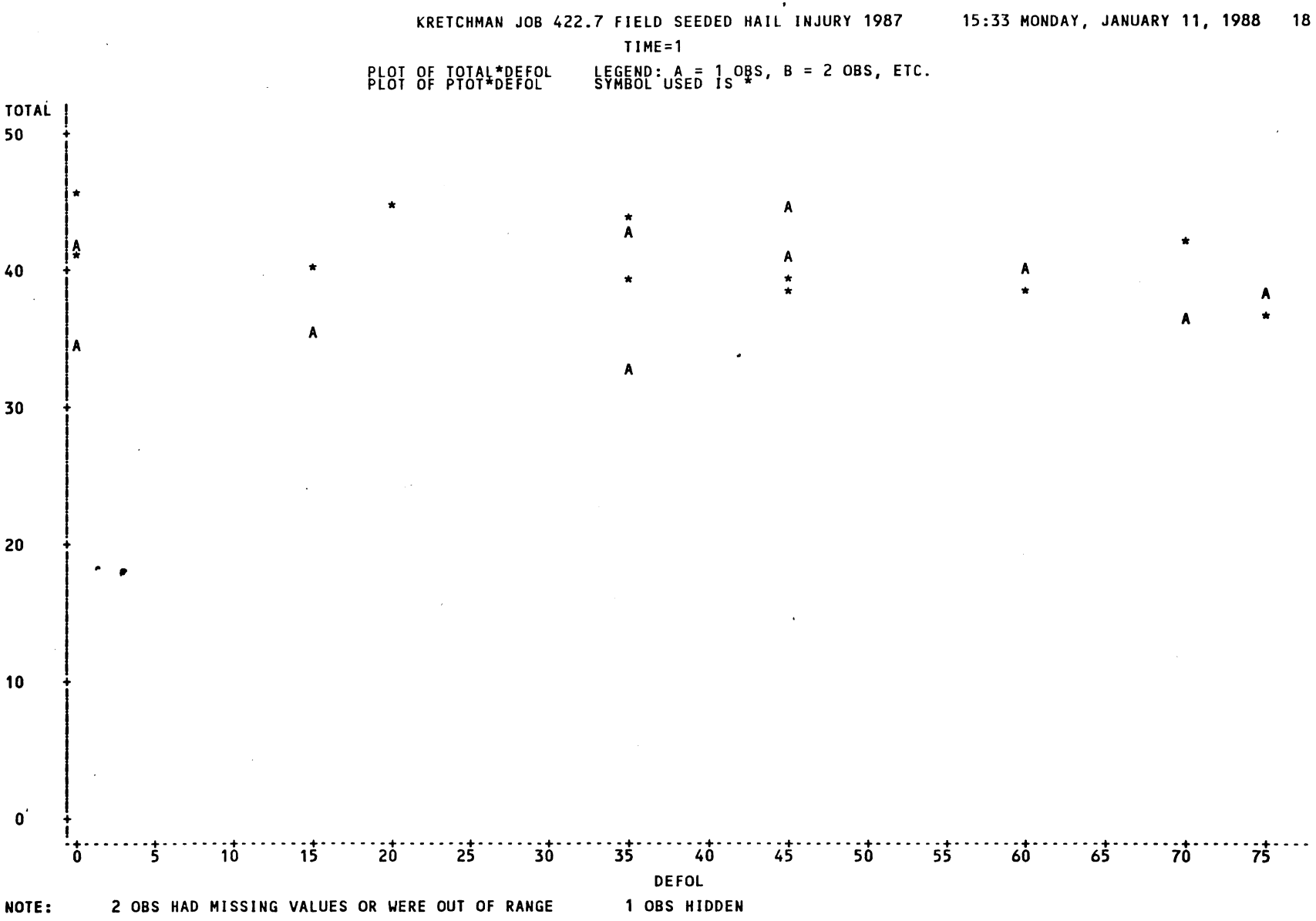


Fig. 33. Relationship of amount of defoliation from hail injury to total fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on July 10.

TIME=2

PLOT OF RED*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PRED*DEFOL SYMBOL USED IS *

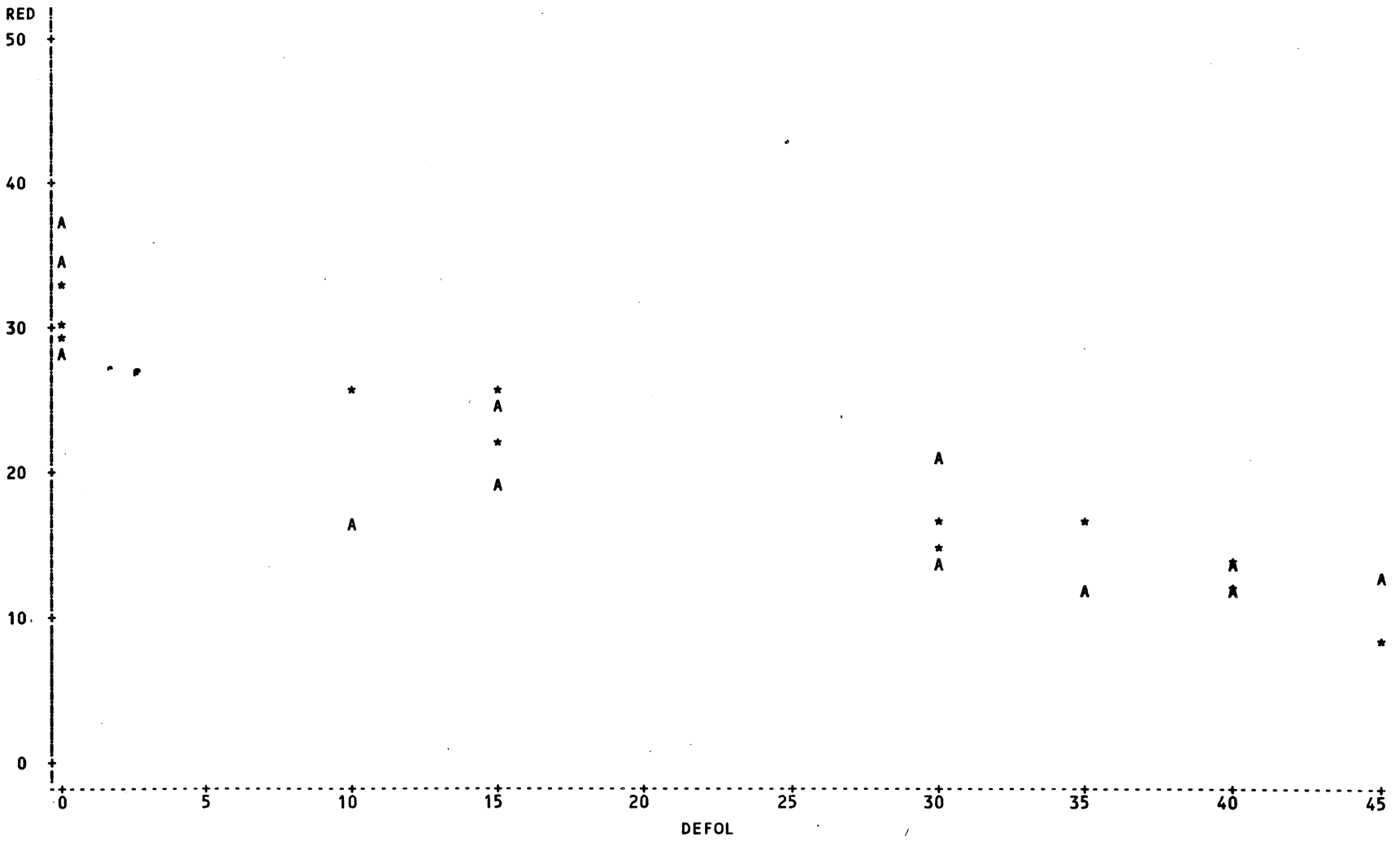
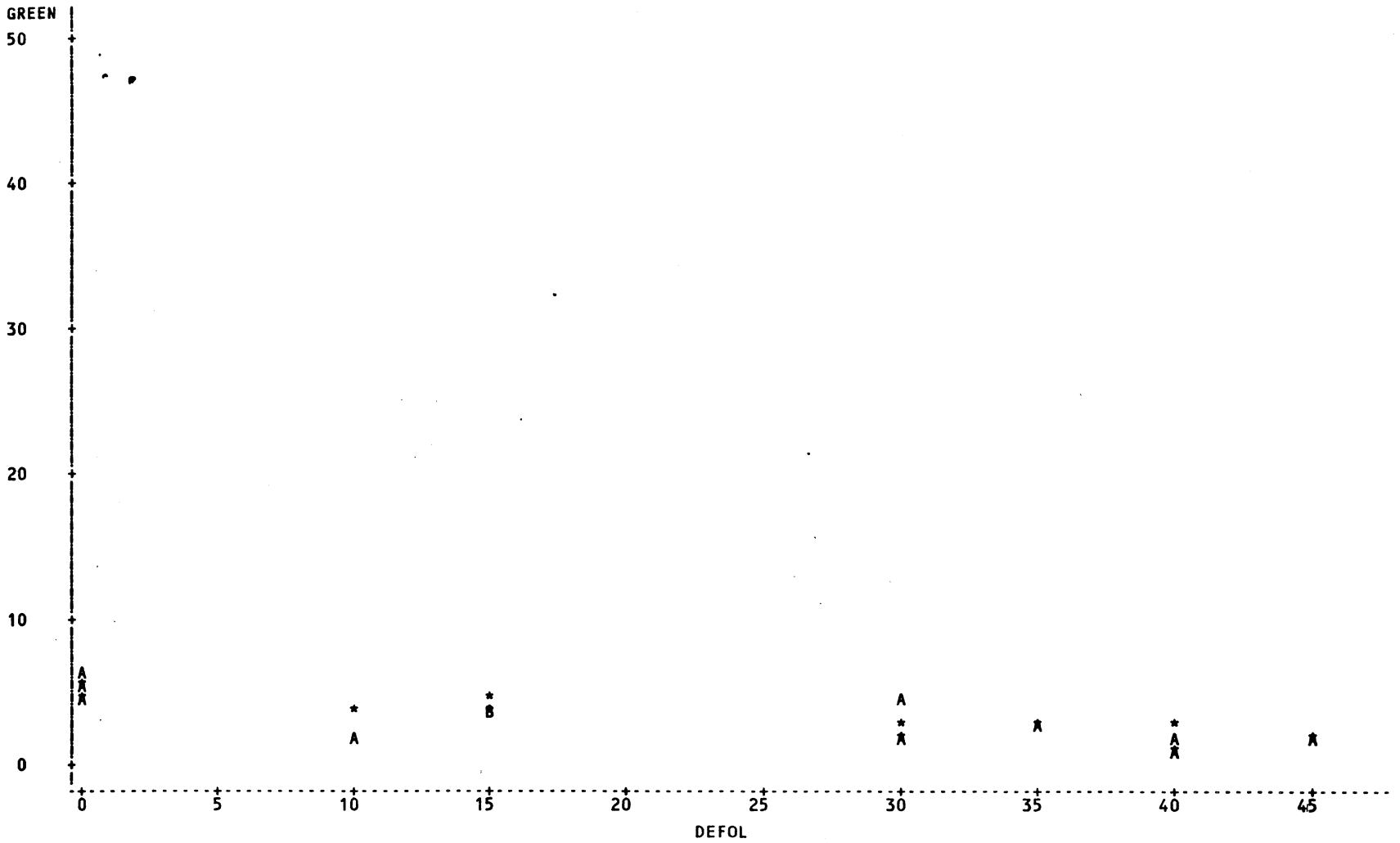


Fig. 34. Relationship of amount of defoliation from hail injury to ripe fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on August 13.

TIME=2

PLOT OF GREEN*DEFOL LEGEND: A = 1 OBS, B = 2 OBS, ETC.
PLOT OF PGREEN*DEFOL SYMBOL USED IS *



NOTE: 1 OBS HIDDEN

Fig. 35. Relationship of amount of defoliation from hail injury to green fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on August 13.

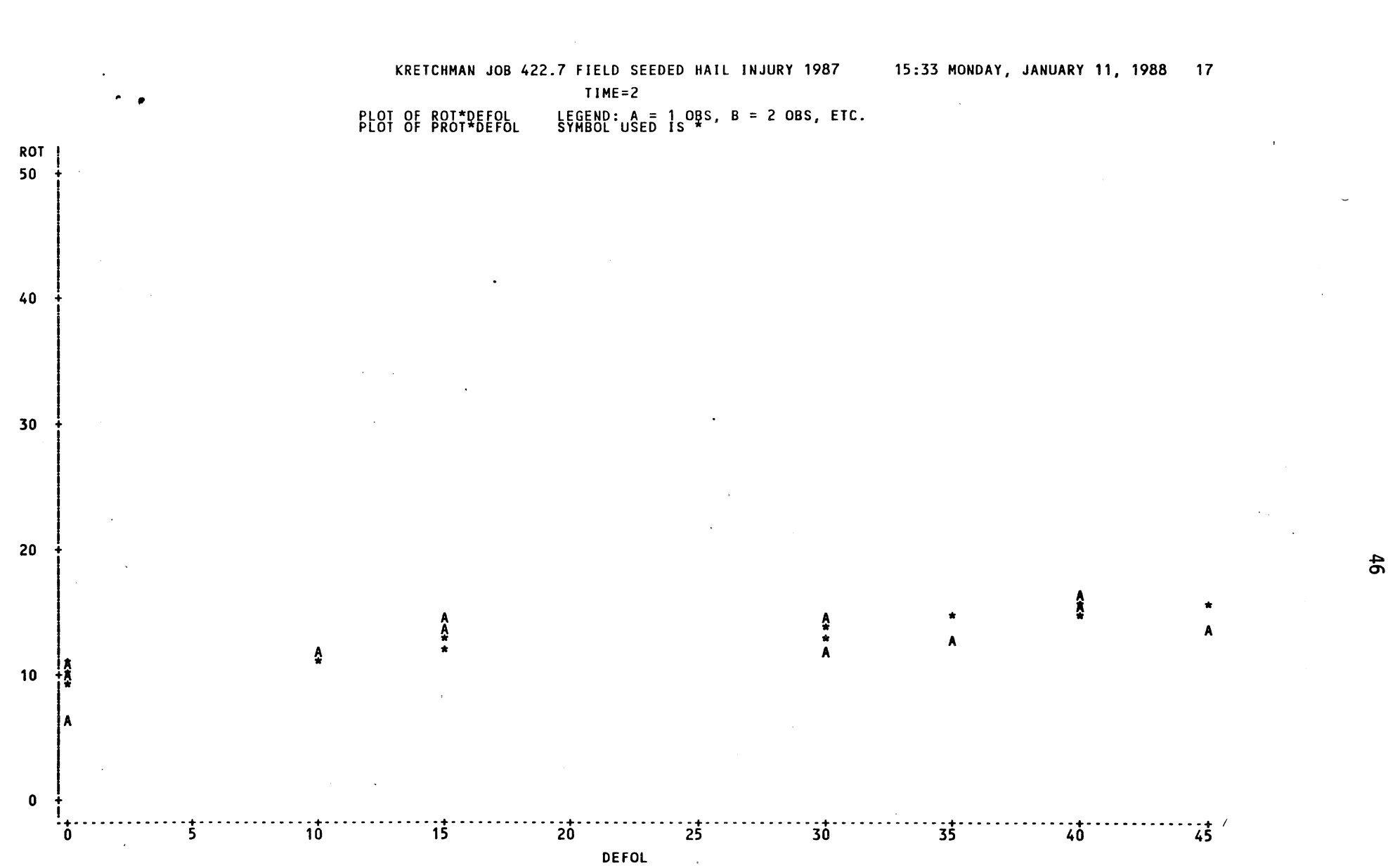


Fig. 36. Relationship of amount of defoliation from hail injury to rotted fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on August 13.

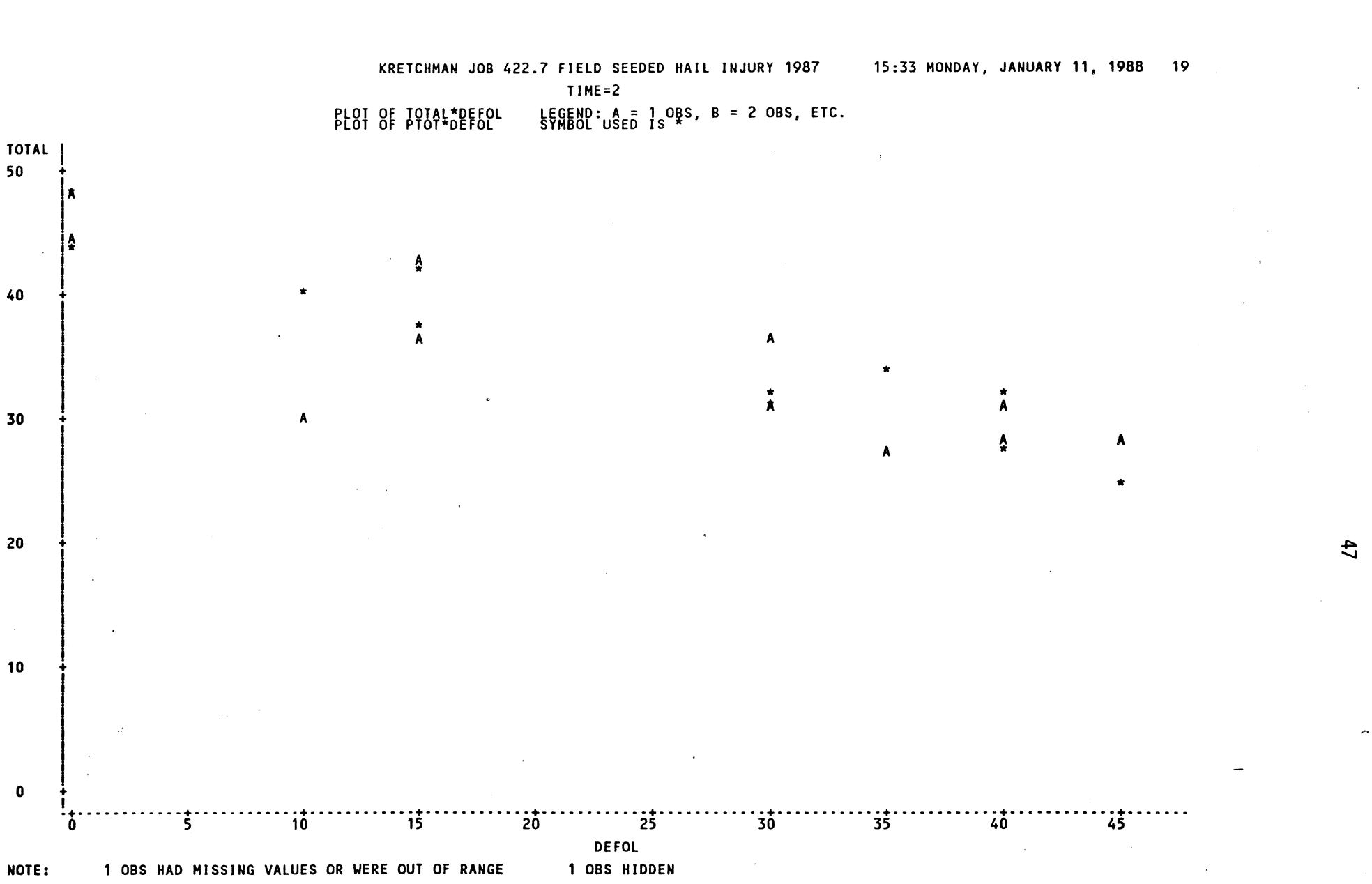


Fig. 37. Relationship of amount of defoliation from hail injury to total fruit yield of field seeded processing tomatoes. Plants were seeded on May 8 and hail treated on August 13.

PROPOSED STAGING OF TOMATO TRANSPLANTS

1. Plant recovery stage axillary shoots less than 2 inches long.
2. Early Vegetative - Primary stem has near 6 inches of new growth, first cluster in bloom, second cluster showing. Axillary shoots 4 inches long and first flower buds visible.
3. Late Vegetative - Primary stem has terminated in flower cluster and may be 12 to 19 inches long and may have 2-4 flower clusters. First cluster fruits may be about 1/4 final size, 4-5 weeks after transplanting. Axillary shoots are up to 12 inches long and have 1 flower cluster in bloom with 2 or 3 flower clusters visible.
4. Maximum flowering for setting of major crop of fruits - fruits are easily visible on first and second cluster of main stem, first cluster fruits may be 3/4 of final size and second cluster fruits are up to half of final size; third and fourth cluster flowers in full bloom. First 2 clusters on axillary shoots are in full bloom, but terminal flower clusters not open. (Usually this period is 5 to 7 weeks after planting, but may be up to 8 weeks.)
5. Snow-ball bloom - all terminal flowers in bloom so plants appear yellow from maximum bloom. However, most previous flowers have set fruits and the terminal flowers usually abscise. Fruits on first cluster of main stem are near full size and second cluster fruits are about half size. Other fruits are about pea size or slightly larger. This usually is 7 or 8 weeks after planting.
6. Early post-bloom and maximum fruit growth. Shortly after stage 4 and during stage 5, fruits will be growing very rapidly after fruit set and this usually lasts around 3 weeks, but this tends to over-lap with stage 7.
7. Fruit sizing and early ripening. During this stage the weight of the fruits cause the shoots to bend to the ground, thus causing the plants to open-up and expose

the stems and fruits. Hail at this time and later could result in the most serious fruit losses from scarring and rotting.

8. Fruit ripening - ripe fruits are accumulating prior to harvest (the first cluster fruits on the main stem are likely over-ripe and completely decayed). This stage usually lasts up to 3 weeks. May be less if Ethrel is used to promote fruit ripening, may be only 2 weeks.

PROPOSED STAGING OF FIELD SEEDED TOMATOES

1. Early vegetative - plants 3-5 inches tall, just becoming well established.
2. Mid-vegetative - plants 6-12 inches tall and first flower buds visible but no flowers open.
3. Late vegetative - plants 12-24 inches tall with flowers open on 2 or more clusters.
4. Early fruit development - period if no more vegetative growth and fruits up to half final size and plants generally erect.
5. Final fruit growth - final stages of fruit growth and plants become prostrate; some fruits beginning to show color.
6. Fruit ripening - plants generally prostrate, fruits ripening for harvest.

E. Simulated Hail - Fresh Market Tomatoes

Plant development for the July 9 hail treatment of planting 1 was plants were about 3 ft. tall with fruits set on 3-4 clusters and the first cluster fruits were nearly full size. Plants of the second planting were 15-18 inches tall with blossoms open on clusters 1 and 2 and a few fruits visible (up to 1/2 inch) on the earliest clusters.

Plants in the earliest planting when treated on July 23, were 3 to 3.5 ft. tall with fruits ripening on the first cluster and 8-10 clusters per plant with fruits at various stages of development. Plants in the second planting were 2.5-3 ft. tall with

heavy bloom present and fruit setting heavily on clusters 2 and 3. Cluster 1 fruits are less than half full size.

Plant defoliation ratings averaged 30.7% for the slight hail treatment, 57.5% for moderate hail and 77.5% for the severe hail treatment.

Harvesting of the first planting was done on July 29, August 7 and August 19; harvest of the second planting was August 31 and September 11.

TABLE 2. Influence of injury from simulated hail on yield of fresh market tomatoes, cv. Sunny, Fremont, planted May 8, 1987.

	Yield-tons/acre from 3 harvests*							
	Treated July 9				Treated July 23			
Treatment	No. 1	No. 2	Culls	Total	No. 1	No. 2	Culls	Total
0-Control	7.6	9.2	20.4	37.2	11.9	8.6	16.3	36.8
Slight	6.7	5.9	17.4	30.0	10.2	4.9	22.6	38.7
Moderate	5.6	2.7	21.6	29.9	9.0	6.2	21.0	36.2
Severe	5.3	1.9	17.4	24.6	6.9	5.1	24.4	36.4
LSD 5%	NS	2.4	3.2	4.8	4.6	2.4	3.2	NS

Harvested July 29, August 7 and August 19

TABLE 3. Influence of injury from simulated hail on yield of fresh market tomatoes, cv. Sunny, Fremont. Planted May 29, 1987.

	Yield-Tons/acre from 2 harvests*									
	Treated July 9					Treated July 23				
Treatment	No. 1	No. 2	Small	Culls	Total	No. 1	No. 2	Small	Culls	Total
0-Control	14.2	8.4	3.8	14.4	40.8	17.5	9.2	3.4	11.9	42.0
Slight	11.8	7.1	2.5	10.9	32.3	9.0	5.8	1.9	22.7	39.4
Moderate	12.2	7.6	3.2	10.6	33.6	10.0	5.2	2.4	22.0	39.6
Severe	8.4	6.4	3.3	8.9	27.0	5.7	3.4	1.0	18.2	28.3
LSD 5%	4.2	1.9	NS	5.3	5.0	4.2	1.9	1.5	5.3	5.0

*Harvested August 31 and September 11.

F. Simulated Hail - Processing Cucumbers

Cucumbers proved very easy to defoliate by the simulated hail machine and the operator had to be very careful to prevent excessive injury, especially to the young plants. Like tomatoes, as the plants became larger, it was more difficult to obtain the high levels of defoliation (Table 4).

Results (Tables 5 & 6) indicate that the hail treatments did, indeed, reduce total yields and dollar value based upon averages received by Ohio growers in 1985-86. Also, the amount of cull fruit increased when the treatments were applied after fruits were present on the plants.

TABLE 4. Range in defoliation of pickling cucumbers from simulated hail. Fremont 1987.

Treatment	Estimated Defoliation (%)		
	Vine Tip	Up to 1 in. diam.	Second wk. of Harvest
Slight hail	15-25	5-15	15-20
Moderate hail	45-55	30-50	30-40
Severe hail	60-90	60-70	55-66

TABLE 5. Influence of simulated hail on yield of pickling cucumbers, 7 hand-harvests, bi-weekly from July 24-August 14, 1987.

Time of Treatment	Treatment	Yield Tons/acre Usable	Culls	$/A
Vine Tip (7-10)	Control	9.45	2.08	1,473
	Slight	8.12	2.16	1,303
	Moderate	6.51	2.23	982
	Severe	6.79	1.30	1,018
Fruit up to 1 in. diameter (7-23)	Control	9.80	2.29	1,536
	Slight	7.42	2.23	1,143
	Moderate	7.14	2.29	1,121
	Severe	6.86	2.01	1,059
Second week of harvest (7-31)	Control	9.31	2.18	1,495
	Slight	7.42	2.29	1,268
	Moderate	6.93	2.25	1,182
	Severe	6.16	2.44	1,011
LSD 5%		0.82	0.39	270

TABLE 6. Influence of simulated hail on yield of pickling cucumbers - time and treatment means.

Treatment	Tons/acre Usable	Culls	$/acre
Control	9.52	2.19	1,501
Slight	7.70	2.23	1,238
Moderate	6.86	2.26	1,095
Severe	6.58	1.92	1,030
LSD 5%	0.98	0.21	157
Time of Treatment			
Vine Tip	7.70	1.94	1,194
Fruit to 1" dia.	7.84	2.20	1,215
2nd wk of harv.	7.42	2.29	1,239
	NS	0.19	NS

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